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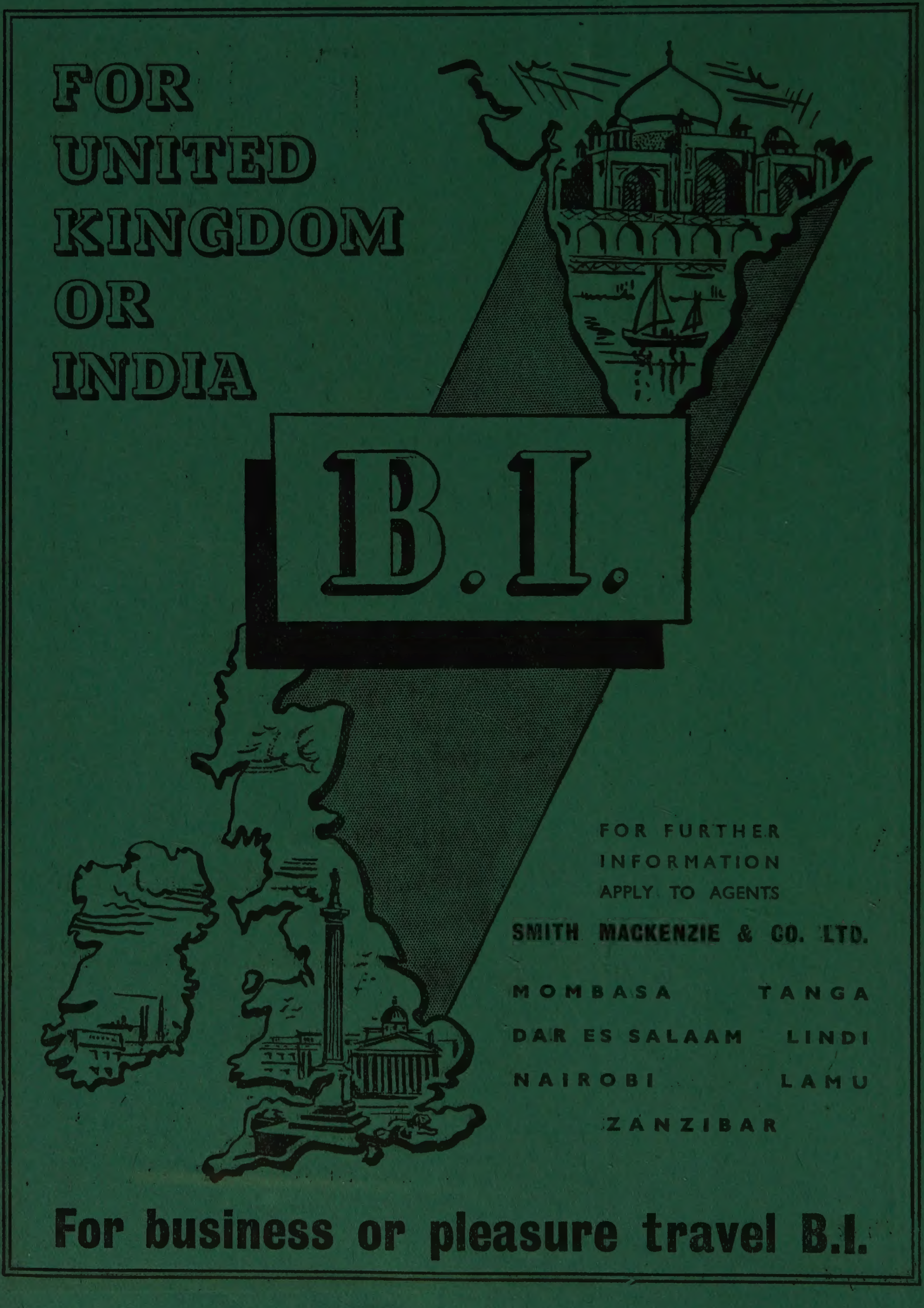

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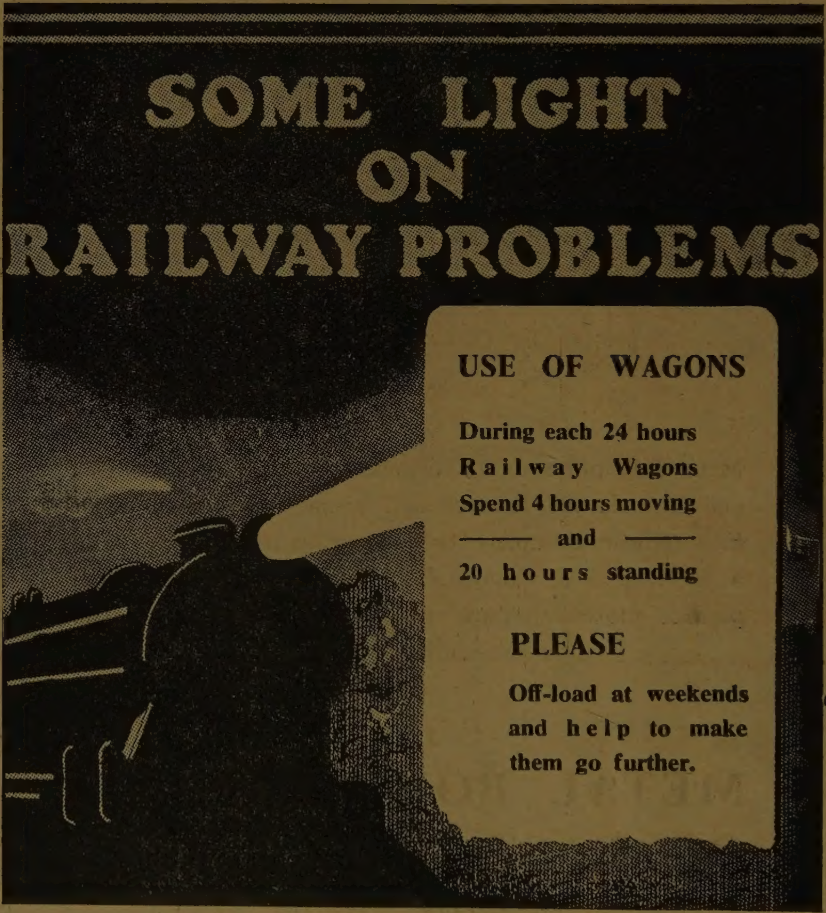

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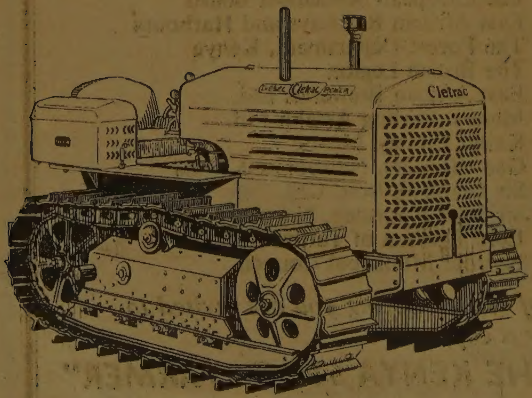

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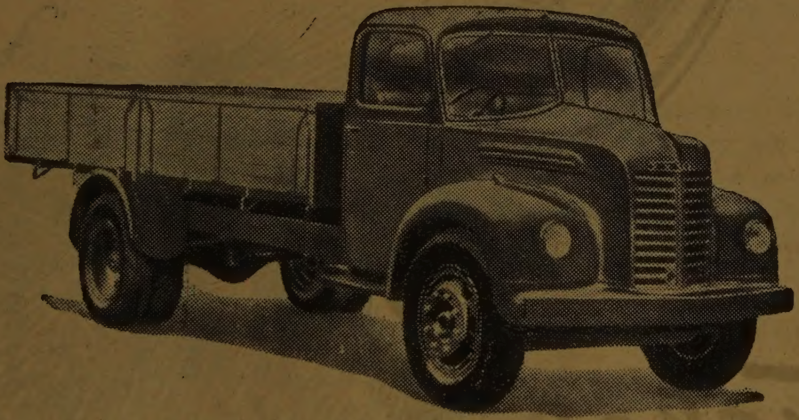

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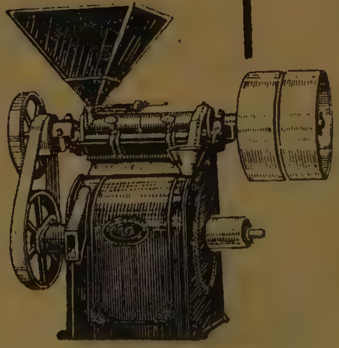

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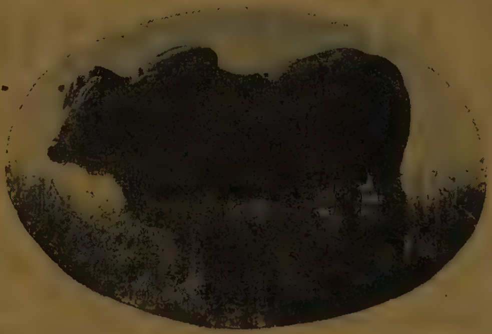

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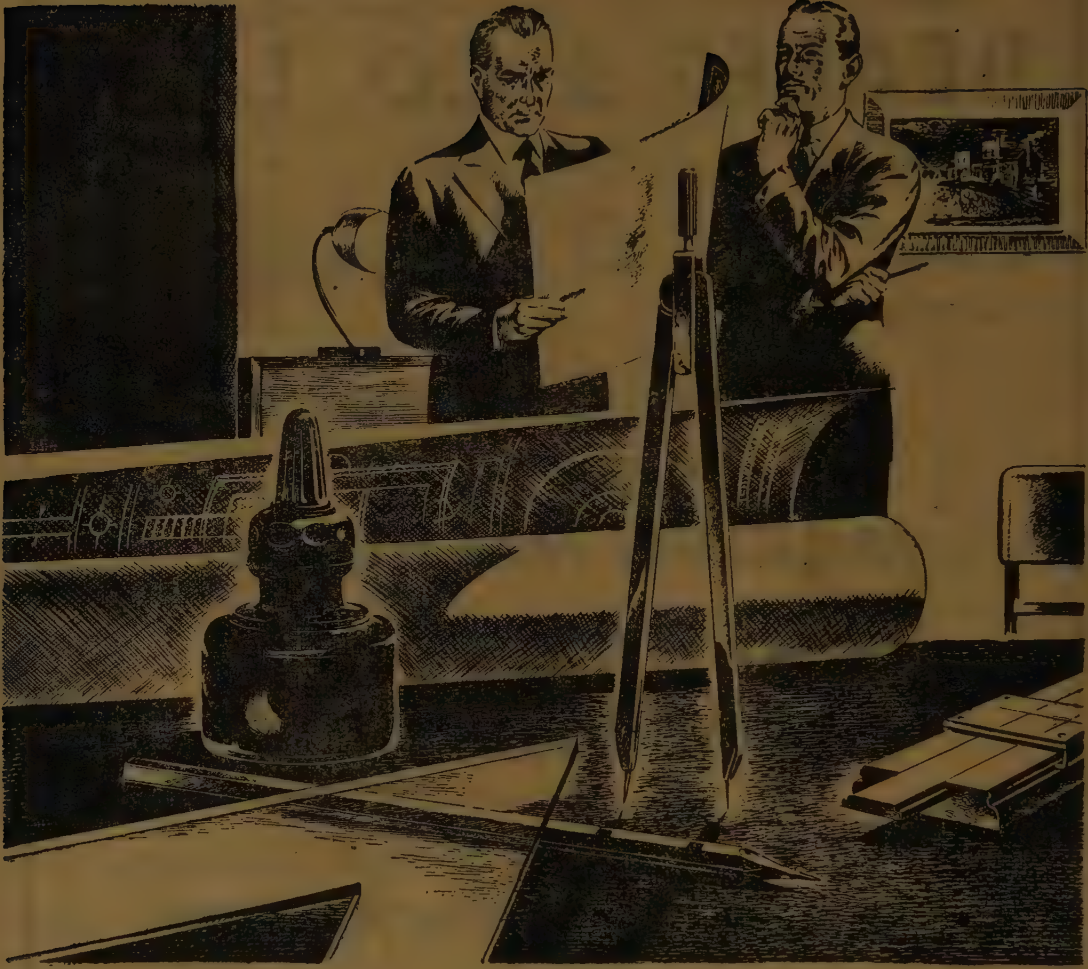

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SOIL FERTILITY SURVEY

In this number we publish an article by Tidbury and Calton on the use of microplot experiments in the soil survey of Zanzibar Island. After the main soil types had been mapped and described, the problem was to find out how these types would respond to fertilizer treatment, and the normal procedure would be to lay down a large number of field experiments with the crops most suited to each district. As this would be costly and time-consuming, the authors made use of the microplot technique devised by Holme, in which small plots, each two feet square, are used in a statistical design, and maize, the indicator crop, is harvested when it is about a foot high, usually four weeks after planting. The weight of green material from different treatments is taken as a measure of the response to fertilizer treatment, and, although the only true criterion of a fertilizer experiment is the mature crop, the microplot method gives an indication of the relative response that may be obtained from different soils, and is of considerable value when correlated with soil analyses.

Microplots have been used as a preliminary to full-scale field experiments, but this application of the method opens up a new field of work in relation to soil surveys. The most usual kind of soil survey is that in which the soil types are classified and demarcated on a map, but, although this is a valuable basic knowledge on which to study the potential value of the soils, it does not give definite indications of the value of the land for agricultural purposes. The soil is evaluated as it is, and its potential fertility as measured by root absorption is not usually studied in the survey.

It is a very great disadvantage that the normal soil survey takes so little account of the potential productivity of the area. For instance, a soil which may be extremely fertile from the soil surveyor's point of view may be extremely infertile from the farmer's viewpoint, if, for instance, the rainfall is so low or so irregular as to limit seriously the crop yield. On the other hand, an infertile soil under a good rainfall might be a much better farming proposition if it responds well to fertilizer applications. In the tropics it is almost a generality that the higher the rainfall the poorer the soil, since a high rainfall means rapid leaching of the plant nutrients with gradual lowering of the fertility. The younger volcanic soils are exceptions to this, as they have not been subjected to leaching for geological periods of time.

In undeveloped tropical countries the relative density of the native farming population is a good guide to the relative productivity of the soils, and the population map of East Africa is particularly striking in this respect. Gillman points out in a previous volume of this Journal (Vol. XI, 1945, p. 86) that two-thirds of the five million inhabitants of Tanganyika live on one-tenth of the land in the region near Lake Victoria; the remaining third of the population occupies one-fifth of the land, and nearly two-thirds of the Territory is uninhabited. Gillman found no correlation between soil type and density of population; he says "A comparative study of the land occupation and soil maps clearly indicates that islands of densest population as well as uninhabited areas are found on identical soils of many types, and, curiously enough, our heaviest concentration of peasants, 475 to the square kilometre (1,235 per square mile) in the Kitobo County of Bukoba, lives on soils of very low natural fertility".

The dense population in the Bukoba District, bordering Lake Victoria, illustrates the difference between natural fertility and potential productivity. Milne studied the area, and in a discussion of the native methods of soil management (this Journal, Vol. IV, 1938, p. 13) he gives the history of the flourishing coffee industry, which was started by Emin Pasha in 1890. The soil is naturally infertile, but by selection through crop failures the natives have concentrated on the relatively less infertile patches, and by replacing more plant food than was removed by the crops they have built up the fertility to a high level. Milne found that it was mineral nutrients rather than organic matter which the soil required, since the unused grassland between the coffee fields, which is now practically unusable, has an adequate supply of organic carbon and nitrogen. The intensively cultivated soil had been enriched over many years by kitchen refuse, firewood ashes, and cattle manure, all of which Milne classes as imported fertility.

This is an example of what can be done to improve a naturally infertile soil under a high rainfall (75 inches per annum). But how can we tell whether it is worth building up the fertility of a poor soil? Long-term field experiments would answer this question in time, but the pressure of population and the need for rapid development of unused areas makes it imperative that the investigational period should be as short as possible. The microplot method provides a quick answer, which, although it cannot be taken as the whole truth, does give some indication of how a soil will respond to better treatment. It enables a rough fertility survey to be superimposed on a soil survey without the additional work and expense which elaborate field experiments would entail, and in large-scale land utilization projects it would be possible to obtain a better picture of the future economic status of the area selected. It might not always be easy to lay down a large number of microplots on an area selected for development, since it may be difficult of access in its undeveloped state, but this is an inherent difficulty with all kinds of field experiments. With modern methods of transport over rough country it should be possible to lay down a sufficient number of experiments to give a much better indication of the potential fertility than can be got by any other means.

We must not forget, however, that no method has yet been found whereby the potential productivity of a soil can be judged accurately. Chemical analysis of a soil merely tells us the amount of available and reserve plant foods; physical analysis will indicate how a soil will hold moisture, and what proportion of that moisture will be available to plants; microplots and short-term field experiments will show how a soil will respond to manurial and cultivation treatments under the particular seasonal conditions of the experiment. None of these methods takes into account the yearly variations of rainfall or the possibility that a soil may slowly be brought to high fertility by building up the organic and mineral reserves. The overall effect of continued good farming is to create in the soil a colloidal complex which will retain moisture which the plant can easily obtain; and also to saturate this humus material, and also the clay particles, with plant food which will not easily be leached out by rain, but which can readily be extracted by plant roots. In East Africa, in common with many other tropical areas, soil moisture is usually the limiting factor, and large reserves of plant nutrients are of little value if there is insufficient rain to allow the crop to utilize them. On the other hand, as Milne showed with the Bukoba soils, organic reserves are useless in themselves if chemical plant foods are not available in sufficient quantity for optimum plant growth.

Thus the immediate response of a soil to manurial treatments, such as is measured by microplot experiments and short-term field trials, is an indication of the first stage in soil improvement—that of ensuring that the supply of chemical plant foods is not the limiting factor. The next stage is to bring the physical condition of the soil into the best possible state for the retention of soil moisture so that the irregularities in rainfall are countered to the greatest possible extent. In the tropics the raising of the organic status of a soil is usually the key problem, since the rapid decomposition of plant residues in the soil hinders the accumulation of organic reserves. Occasional large dressings of cattle manure will not solve this problem, and frequently repeated large dressings are too costly to be applicable to most farming systems. Rotation under grass seems to be a possible solution, since the decomposition of plant residues *in situ* avoids the expense of composting and spreading organic manures, but a thin grass cover will not provide sufficient material to build up adequate organic reserves, and thus a prerequisite of grass rotation must be that it should be a lush grass cover, from which a large amount of plant residues will be ploughed into the soil.

Even with these limitations in mind, the use of microplot experiments as a complement to a soil survey is of great value, since at least some indication is obtained as to whether or not it would be wise to lay down long-term experiments. In the wider expanses of East Africa the method would be even more valuable in indicating which soil types should be studied in more detail.

D.W.D.

THE USE OF MICROPLOTS IN A RECONNAISSANCE SURVEY OF THE NUTRIENT STATUS OF THE SOILS OF ZANZIBAR ISLAND

By G. E. Tidbury, Agricultural Officer, Zanzibar, and W. E. Calton, Government Chemist, Zanzibar

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The soil microplot is a method of assessing the response of a soil to external factors, such as the application of fertilizers, in terms of the green weight of a particular plant, the most common one being maize. The chief value of the microplot lies in its cheapness and the rapidity with which a result is obtained as compared with the orthodox field experiment. Several microplots can be established for the same cost as one large field trial and, within the recognized limitations of the microplot method, give results which are particularly acceptable because they are based on a number of assays.

Microplots were first described by Holme (1944) who used this method to assess the needs of sugar cane fields in Jamaica for the major plant nutrients. He was able to combine the results of a large number of microplots so as to indicate the form of the curve representing Liebig's Law of Diminishing Returns and to determine the value of the constant in the formula of the curve. This enabled him to forecast with considerable accuracy increases in the weight of cane which would result from given dressings of sulphate of ammonia.

In the discussions which followed the publication of this work it was pointed out by Professor F. Hardy that, "The second aspect of the microplot was its use as a means of soil survey . . ." It is this second use of the microplot which is described in the present paper.

During recent years it has become necessary to make a closer study of the origin and development of Zanzibar soils. When Calton (1948) outlined a scheme of classification of these soils, in which a number of clearly differentiated types were distinguished, the question arose whether these soil types were of differing nutrient status to the extent of certain types being more markedly deficient in any of the major plant nutrients than others.

It was hoped that a number of microplots distributed over the island would not only provide an answer to this question but also speed up the whole programme of fertilizer trials in Zanzibar by indicating which, if any, major nutrients would be of minor importance in designing future experiments on any particular soil type.

ZANZIBAR SOILS

A walk across the centre of Zanzibar Island from West to East traverses the two most important main soil types, each of which is subdivided into minor divisions. The sequence is roughly as follows:—

On the western side the soil is a sandy loam, in places greyish, and poorly drained. As the low (300 ft.) ridge is reached it changes to a redder, freely draining soil of great depth. The soils of this group are non-calcareous and are derived from the re-sorted debris of the East African Basement Complex rocks. They have been called *"changa"* soils by Calton.

Further east, darker red soils are found which are derived from limestone. As one proceeds eastwards these soils become browner and more humic, and their depth decreases until raw coral rock is observed on the surface and the real soil becomes confined to pockets in a wide zone of karst-like country.

These soils, called *"kinongo"* soils, are derived from limestone deposited in Pliocene to recent times. A maturity sequence is observed in this group, the oldest areas having weathered most deeply, the shallowest areas, which lie closest to the sea, hardly at all. Near the actual beaches a sandy gravel composed almost entirely of calcium carbonate is often found and is considered a related type.

A third important soil type is observed in certain scattered and isolated areas. This is called *"namo"* and is a sticky, heavy soil whose character is determined by the nature of its marly or clayey parent material.

The soil types of Zanzibar Island can thus be shown systematically as follows:—

Group I, Kinongo Soils.—Soils on limestones, weathering without check to drainage and forming a maturity sequence. They are subdivided as follows:—

(*a*) *Deeper Kinongo.*—Deep, loamy to rather heavy, eluvial, neutral to slightly acid, red soils.

(*b*) *Shallower Kinongo.*—Shallower but in other respects resembling the above.

(*c*) *Wanda.*—Very shallow, humic, neutral to slightly alkaline, brown soils.

(*d*) *Maweni.*—Rudimentary soils in limestone pockets, highly humic, neutral to slightly alkaline, black in colour.

(*e*) *Swampy Wanda.*—A related type, being a waterlogged variant with a deeper profile. Usually a shallow, peaty, grey clay under swampy forest.

(*f*) *Shell Sands.*—A grey, incoherent, fine grained gravel. A geological deposit functioning as a soil.

Group II, Changa Soils.—Soils on non-calcareous sediments, draining according to texture and topography. In these soils maturity is less useful as a factor in differentiating between the minor types. Drainage is the determining factor and the consequent relationship is a catenary one. These soils are subdivided as follows:—

(*a*) *Reddish Changa.*—A very deep, freely draining, sandy to heavy soil possibly with concretions at depth.

(*b*) *Brownish Changa.*—A deep, moderately well drained, loamy to heavy soil, usually grey mottled at depth.

(*c*) *Yellowish Changa.*—Deep but sluggishly draining, loamy to heavy soils, blue-grey mottled at moderate depth.

(*d*) *Greyish Changa.*—Deep, sandy to silty soils with a permanent high water table. The topsoil is peaty and black concretionary material is found just above the water table.

(*e*) *Sandy Changa.*—More or less pure sands, akin to the reddish and brownish changa soils but dominated by their sandy parent material.

Group III, Namo Soils.—These are dominantly heavy, cracking soils, some definitely of Rendzina type, others less certainly calcareous, with some parent material factor impeding drainage. They occur in large isolated patches which vary considerably, the best providing excellent rice land of high water-holding capacity.

Prima facie we should expect the kinongo soils to be the most fertile although root room and moisture reserve must suffer in the shallower types and in these also the presence of large quantities of calcium carbonate may lead to lime-induced deficiencies.

In the changa soils, which are derived from the acid gneisses of the East African Basement Complex we should expect a general nutrient poverty due to the breakdown and resortment of the original rocks by water, and their strong leaching since their emergence as soil. The East African Basement Complex however contains considerable amounts of potash felspar which still survive in some of the Zanzibar sediments so that one would expect this class of soils to have some potash reserves.

The fertility of namo soils must depend essentially on the nutrient status of the parent material but this is entirely subject to adequate drainage. The distribution of the main soil types in Zanzibar Island and the location of the microplots are shown in the accompanying map.

THE MICROPLOT TECHNIQUE

The technique of the microplot and the presentation of the results have been described by Holme (1944) and as far as the design and analysis is concerned the microplot is simply an orthodox field experiment in miniature. The microplot is divided into blocks and plots which are randomized in the same way as in the field trial but each individual plot in the experiment is only 2 ft. by 2 ft. in area and is surrounded by an untreated guard area 2 ft. in width on all sides.

The design of a microplot may be the same as any normal lay-out of a field trial and in the experiments used in this survey a factorial design for five factors, at nil and one level, without replications was used. This design is described by Yates (1937) and is a most useful type for exploratory work, error being assessed from the high order interactions and enabling the investigator to test the significance of the mean responses to the main factors and to the first order interactions.

The five factors used in these experiments were as follows:—

(1) Nitrogen as sulphate of ammonia at 336 lb. per acre.

(2) Phosphate as sodaphosphate at 235 lb. per acre.

(3) Potash as sulphate of potash at 113 lb. per acre.

(4) Lime at 1 ton per acre.

(5) Humus as compost at 5 tons per acre.

The first three dressings were intended to supply roughly the same quantities of N, P_2O_5, and K_2O per acre. Each microplot consisted of 32 plots set out in an area of 30 ft. by 14 ft., which was first cultivated and raked before marking out in 2 ft. squares. Alternate squares in alternate rows were the actual plots.

In each plot the requisite quantity of fertilizer was mixed with the top soil in which three drills were made and maize seed sown. (Holme, however, preferred to apply the fertilizer to the partially covered drills after the seeds had been sown.) It is of considerable importance that the depth of sowing should be uniform throughout a series of experiments, and indeed the greatest care should be taken to ensure complete uniformity of treatment even in minor details of technique. Fifteen seeds of maize were sown in each drill and covered with soil.

In Zanzibar it has been found that the dry season is suitable for microplot trials, and therefore the plots were watered twice daily at the rate of one cigarette tin of water to each two-foot square.

After eight days the maize seedlings were thinned to a uniform number in each square, which should not exceed thirty nor be less than twenty-five. Daily watering continued until the plots were reaped at thirty days. Reaping consisted of pulling up the plants in each square together with their roots, shaking them free from soil, counting them and weighing. If considerable variation in plant number is found the plot is best abandoned. Results were statistically analyzed and the responses expressed as percentage increases or decreases in weight above or below the mean of each experiment.

Although Holme does not consider tests for statistical significance of prime importance in work with microplots—the magnitude of the response enabling him to construct the response curves—the present writers preferred to carry out statistical analyses on all the results. In the tables therefore, statistical significance above a level of $P=0.05$, is indicated by printing the percentage increases and decreases in italic type. Increases and decreases have been displayed in separate tables for ease of study. The results of the microplot experiments are given in Tables III and IV.

DISCUSSION

The results of the microplots show remarkable consistency and, in the opinion of the writers, give a more forceful impression of the needs of each soil type than could have been given by the relatively few full-scale trials which could have been undertaken with the same resources. A second characteristic is the magnitude of the differences, some 113 significant responses being observed in 30 experiments. Thirdly the results indicate very clearly a marked differential response to phosphate and potash depending on the origin of the soil type.

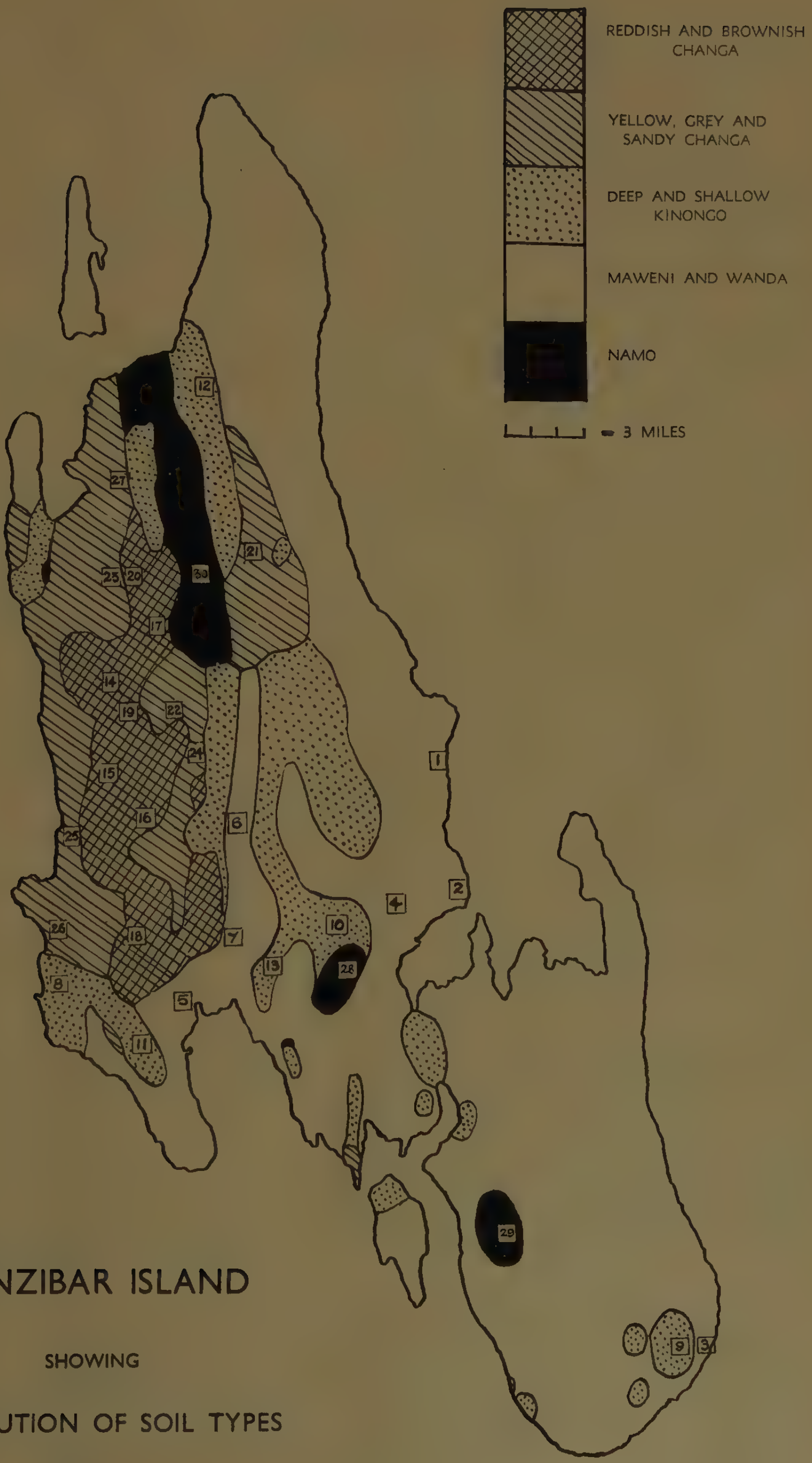
The responses to each factor are discussed below, but it should be borne in mind that discussion based on the results of these microplots, especially where possible deficiencies of minor elements are concerned, depend mainly on the behaviour of a single crop.

Nitrogen.—Sulphate of ammonia caused very large and significant increases in the weight of the maize plants on all soil types. The greatest increases were observed on wanda and shallow kinongo soils.

An obvious criticism of the microplot method of assessing soil needs is that the criterion—green weight of young maize—is unlikely to yield similar results to those which might be obtained were the crop taken to maturity and the grain harvested. It is of interest in this respect to compare the results of three field trials conducted at Hanyegwa Mchana on wanda soil and adjacent to the site of the microplot.

In these experiments dressings of sulphate of ammonia increased the yields of maize and sorghum by 36 per cent and 9 per cent respectively. Compost increased the yields of maize and cowpeas by 17 per cent and 24 per cent respectively. All these increases were statistically significant and are very similar to the microplot results for the wanda soils.

Furthermore, as will be observed later nitrogen on changa soils also caused similar responses in both microplots and field trials.



ZANZIBAR ISLAND

SHOWING

DISTRIBUTION OF SOIL TYPES

AND

LOCATION OF MICROPLOTS

TABLE I

THE EFFECTS OF ANNUAL DRESSINGS OF SULPHATE OF POTASH

	SEASON			
	First	Second	Third	Fourth
No. of fruits per acre	—576*	—112	+112	+268*
Total weight of fruits per acre (tons)	—1·594	—0·390	+0·558	+1·393
Average weight of fruits (lb.)	—0·208	—0·178	+0·322	+0·925

*P=0·05.

Phosphate.—The differential response to dressings of sodaphosphate indicates that, whereas changa soils are clearly in need of dressings of phosphates, kinongo soils apparently have sufficient reserves of this element. This supports the conclusion that changa soils are derived from the debris of mainland rocks—themselves deficient in phosphates—whereas we should expect young soils derived from the coraline deposits of sea organisms to be relatively rich in phosphates.

Here again, field experiments on typical reddish changa soils at Kizimbani bear out the results of the microplots. For example, dressings of sulphate of ammonia, sodaphosphate and compost increased the yield of maize by 27 per cent, 23 per cent and 24 per cent respectively over a mean yield of 1,161 lb. per acre.

Namo soils also respond slightly to phosphates.

Potash.—The response to sulphate of potash is the reverse of the phosphate picture. Kinongo soils from the most immature to the deeper, more fully weathered types are apparently deficient in potash. On changa soils, on the other hand, the more common result is a slight but insignificant negative response to potash.

The origin of the changa soils is again emphasized, for many of the mainland soils have apparently sufficient reserves of potash and are derived from rocks in which potassic felspars predominate.

It is of interest to record, however, that continuous cropping of changa soils may exhaust the relatively large reserve of potash, demand possibly exceeding the rate at which it becomes available by the weathering of felspars. This was shown by Tidbury (1944) in experiments with pineapples at Kizimbani (Table I).

Under conditions of continuous cropping cloves (Yates, 1937) also respond to potash on changa soils.

Lime.—The role of lime in Zanzibar soils is far from clear. We would expect positive responses on changa soils because these soils are all acid, with figures for pH normally near 5.0. Yet no significant positive responses were obtained in the microplots on changa soils, and several significant decreases ranging from 20 per cent to 27 per cent reduction in growth weight were observed.

The interactions between lime and the other factors, particularly nitrogen, were frequently most strikingly negative and a possible explanation is that changa soils, if not all Zanzibar soils are deficient in certain minor elements and that this deficiency is emphasized in the presence of lime. Nevertheless it is of interest to record that the crop of sweet potatoes planted after the maize at Kizimbani, the yields of which were recorded in Table IV, showed a marked positive response to lime to the extent of increasing yield by 1,669 lb. per acre in a 7,858 lb. crop.

Humus.—Dressings of compost caused large increases in growth on all the soil types tested including the small namo group.

It is unlikely that these results were entirely due to the nitrogen content of the compost as an analysis of this material as shown in Table II indicates a relatively poor nutrient status in terms of major elements:—

TABLE II

Analysis of Compost (over-dry basis)

	%
Moisture	33.60
Nitrogen (N)	0.58
Phosphate (P_2O_5)	0.25
Potash (K_2O)	0.46
Silica (SiO_2)	69.30
Calcium (Ca)	1.90

The strong positive response to compost is also borne out in the field experiments performed this year both at Hanyegwa Mchana and Kizimbani which were described above. Furthermore, striking increases in the yield of rice were observed this year on greyish changa soil due to dressings of 5 tons of compost per acre.

In four separate experiments at Mahonda and Kisongoni increases of 14 per cent, 29 per cent, 11 per cent and 29 per cent were obtained in crops averaging one ton of paddy per acre.

It is likely, however, that the beneficial effects of compost in these trials included its ability of increase the moisture-retaining power of the soil, a factor of considerable importance with semi-upland rice. Minor elements and beneficial microbiological effects may also be involved in the compost responses.

THE INTERACTIONS BETWEEN THE MAIN FACTORS

Certain of the interactions caused increases which, as was expected, enhanced the added effects of the main elements. Thus the interaction between phosphate and nitrogen was positive and statistically significant on many of the changa soils, increasing growth in several cases by as much as 25 per cent over and above the effects of the main factors.

This is, of course, a well-known relationship and on typical changa soil at Kizimbani it has been observed in field experiments that increases in yield due to nitrogen are sometimes observable only in the presence of adequate supplies of phosphate.

In contrast, the interaction between nitrogen and potash rarely attained significance but was, in general, and as might be expected positive on the kinongo soils and negative on the changa soils.

The relationship between nitrogen and lime is the most striking of all the interactions. Severe reductions in growth were observed on all soil types as result of this interaction and the negative response reached its lowest levels on the poorer changa soils.

With lime alone and lime in combination with all the other factors, N, P, K, and H, marked though not always significant decreases in yield occur. This would suggest that iron and possibly other minor elements such as Cu, Mo, Zn, etc., may be generally deficient in Zanzibar soils. On general grounds the shallow kinongo soils could be expected to show iron deficiency by reason of their high lime content. The redder changa too might favour iron deficiency but in this type it might be manganese induced. Proof of iron deficiency on wanda soils at Hanyegwa Mchana has been obtained by ameliorating the condition of chlorotic cashew and wattle seedlings by ferrous sulphate sprays (Dept. of Agric., Zanzibar, 1948). By growing cashew seedlings in pots it has been possible to show deficiency symptoms, which respond to iron in soils from Dunga Road (wanda), Chukwani (shallow kinongo) and Mkwajuni (deeper kinongo). A soil from Selem (reddish changa) has also shown what appear to be characteristic iron deficiency symptoms and responds to iron treatment.

It will also be observed that a consistent negative interaction occurs with K and H. On the hypothesis that iron and possibly other minor elements are generally deficient the beneficial responses to compost might well be due to the local acid or reducing conditions it could induce favouring the mobilization of iron. A high level of K might, as Lindner and Harley (1944) suggest, cause iron deficiency by replacing iron in the enzyme responsible for chlorophyll formation. There is some indication also of a depressive effect of K alone on the Changa type which are presumably well supplied with potash.

SUMMARY

A reconnaissance survey is described in which a series of microplots were used to explore the nutrient status of the main soil types of Zanzibar Island. It was found that all soil types responded positively to applications of sulphate of ammonia and compost but several negative responses were recorded for dressings of lime.

Soils derived from the weathering of limestone responded markedly to potash and not to phosphate. Other soils, however, derived from the debris of mainland rocks, appeared to be deficient in phosphate and not potash.

The first order interactions between the main factors were also considered and, of these, a strong negative interaction between sulphate of ammonia and lime was observed on all soil types.

Very frequent though not always significant negative interactions were also found with lime in combination with all other factors and suggest the possibility of a general iron and/or other minor element deficiency.

TABLE III

SOIL MICROPLOTS

PERCENTAGE INCREASES IN GREEN WEIGHT OF MAIZE

SOIL TYPE		PLACE	MAIN EFFECTS								FIRST ORDER INTERACTIONS						
Main Group	Sub-group		N	P	K	Ca	H	N x P	N x K	P x K	N x Ca	P x Ca	K x Ca	N x H	P x H	K x H	Ca x H
Kinongo Soils	Shell Sands	1. Uroa	*43*	1	—	3	5	7	1	—	—	—	—	—	11	—	4
		2. Chwaka	*29*	8	*24*	—	—	8	1	—	—	—	11	—	1	—	—
	Wanda	3. Makunduchi shore	*63*	—	*14*	—	*31*	—	*11*	—	4	2	3	*12*	—	—	—
		4. Hanyegwa Mchana	*128*	18	16	11	12	1	—	9	—	7	9	*26*	—	—	—
		5. Kisakasaka	*97*	—	—	3	*20*	8	—	6	—	8	2	—	—	—	2
		6. Dunga	*85*	1	*13*	—	*24*	—	11	4	—	—	—	*25*	—	—	4
	Swampy Wanda	7. Kibonde Mzungu	*72*	—	—	—	13	—	—	—	4	11	—	5	1	—	6
	Shallow Kinongo	8. Chukwani Road	*144*	—	10	—	*21*	—	8	6	—	4	—	*15*	3	—	2
	Deeper Kinongo	9. Makunduchi village	*83*	10	*25*	—	*29*	6	15	*18*	—	4	3	15	—	*17*	6
		10. Ndijani	*83*	—	*16*	1	*18*	—	2	—	2	—	—	8	2	—	10
		11. Kombeni	*62*	7	*42*	—	*40*	—	14	3	—	—	—	12	13	—	2
		12. Mkwajuni	10	5	9	—	*16*	10	6	5	3	—	*18*	*21*	—	—	—
		13. Tunguu	14	10	1	*17*	*18*	4	11	4	—	6	—	—	—	—	3
Changa Soils	Reddish Changa	14. Selem	9	*40*	5	—	*27*	—	—	4	—	—	—	—	9	—	—
		15. Kidichi	*33*	*33*	—	—	*26*	8	9	—	7	—	2	9	9	—	—
		16. Kianga	*35*	9	15	—	21	7	—	2	—	—	14	1	—	—	—
	Brownish Changa	17. Kichwele	*68*	*35*	—	6	*32*	*28*	—	—	—	—	—	*13*	3	—	—
	Yellowish Changa	18. Fuoni	*78*	—	5	6	*14*	—	2	3	—	—	7	—	9	—	7
	Greyish Changa	19. Mkenyageni	*50*	9	—	6	*24*	*14*	—	3	—	—	—	*14*	1	—	4
		20. Mahonda (upper)	*25*	*20*	10	3	*14*	5	—	1	—	—	6	—	—	—	—
		21. Kisongoni	*31*	*25*	—	—	*19*	*24*	3	—	—	1	2	8	14	—	—
		22. Bumbwi Sudi	*39*	18	—	12	6	15	—	16	5	—	5	—	—	—	—
		23. Mahonda (lower)	*52*	*33*	—	—	*41*	*26*	—	—	—	—	17	15	—	—	—
	Sandy Changa	24. Kinuni Moshi	*51*	9	11	3	*25*	6	7	—	—	—	—	12	2	—	—
		25. Mtoni	*82*	16	—	—	*21*	11	—	—	—	—	—	9	—	—	—
		26. Migombani	*71*	10	*34*	—	*42*	13	18	—	—	4	—	*29*	—	—	—
		27. Donge (west)	*61*	3	9	—	10	8	—	3	—	—	11	7	—	3	—
Namo Soils	Namo	28. Cheju	*95*	12	—	2	*39*	9	—	—	—	4	7	22	5	—	—
		29. Muyuni	*43*	5	4	—	6	4	*8*	—	—	—	—	1	4	—	—
		30. Mgambo	*77*	*15*	5	—	*36*	*18*	3	4	—	—	—	22	—	6	2

TABLE IV

SOIL MICROPLOTS
PERCENTAGE DECREASES IN GREEN WEIGHT OF MAIZE

SOIL TYPE		PLACE	MAIN EFFECTS								FIRST ORDER INTERACTIONS						
Main Group	Sub-group		N	P	K	Ca	H	N x P	N x K	P x K	N x Ca	P x Ca	K x Ca	N x H	P x H	K x H	Ca x H
Kinongo Soils	Shell Sands	1. Uroa	—	—	13	—	—	—	—	4	3	*15*	8	3	—	1	—
		2. Chwaka	—	—	—	—	9	—	—	5	2	*12*	—	9	—	11	10
		3. Makunduchi Shore	—	—	—	2	—	—	—	2	—	—	—	—	*13*	10	*15*
	Wanda	4. Hanyegwa Mchana	—	—	—	—	—	—	9	—	14	—	—	—	7	9	14
		5. Kisakasaka	—	6	6	—	—	—	5	—	4	—	—	—	7	9	—
		6. Dunga	—	—	—	10	—	1	—	—	11	4	10	—	3	11	—
	Swampy Wanda	7. Kibonde Mzungu	—	8	1	1	—	3	3	3	—	—	*19*	—	—	3	—
	Shallow Kinongo	8. Chukwani Road	—	3	—	8	—	4	—	—	*15*	—	7	—	—	8	—
		9. Makunduchi village	—	—	—	13	—	—	—	—	*20*	—	—	—	10	—	—
		10. Ndijani	—	—	—	—	—	—	—	3	—	—	7	—	—	6	—
	Deeper Kinongo	11. Kombeni	—	—	—	7	—	3	—	—	*31*	5	*26*	—	—	*20*	—
		12. Mkwajuni	—	—	—	3	—	—	—	—	—	6	—	—	4	9	12
		13. Tunguu	—	—	—	—	—	—	—	—	8	—	4	4	8	1	—
Changa Soils	Reddish Changa	14. Selem	—	—	—	*27*	—	—	2	—	7	*26*	6	2	—	1	*16*
		15. Kidichi	—	—	13	11	—	—	—	7	—	19	—	—	—	—	6
		16. Kianga	—	—	—	—	—	—	4	—	*23*	7	—	—	15	11	5
	Brownish Changa	17. Kichwele	—	—	4	—	—	—	6	*12*	*12*	—	*24*	—	—	5	6
	Yellowish Changa	18. Fuoni	—	1	—	—	—	—	—	—	5	4	—	*14*	—	1	—
		19. Mkenyageni	—	—	3	—	—	—	*13*	—	9	6	5	—	—	*15*	—
		20. Mahonda (upper)	—	—	—	—	—	—	6	—	*15*	3	—	—	—	8	11
	Greyish Changa	21. Kisongoni	—	—	5	*24*	—	—	—	3	10	—	—	—	—	12	5
		22. Bumbwi Sudi	—	—	8	—	—	—	5	—	—	16	—	19	8	23	14
		23. Mahonda (lower)	—	—	3	*20*	—	—	4	6	*28*	12	—	—	7	4	13
		24. Kinuni Moshi	—	—	—	—	—	—	—	5	—	10	—	—	—	*17*	3
	Sandy Changa	25. Mtoni	—	—	4	17	—	—	3	10	*24*	23	14	—	1	4	6
		26. Migombani	—	—	—	15	—	—	—	7	20	—	7	—	4	1	*29*
		27. Donge (west)	—	—	—	4	—	—	1	—	*25*	3	—	—	3	—	1
Namo Soils	Namo	28. Cheju	—	—	1	—	—	—	4	—	—	—	—	—	—	6	—
		29. Muyuni	—	—	—	4	—	—	—	—	5	3	—	—	—	3	2
		30. Mgambo	—	—	—	8	—	—	—	—	*13*	1	8	—	2	—	—

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REVIEW

THE FRUIT, THE SEED AND THE SOIL.—*Collected John Innes Leaflets. Prepared by the staff of the John Innes Horticultural Institute. Second Edition, 1949, price 3s. 6d. Published by Oliver and Boyd, 98 Great Russell Street, London, W.C.*

Nine leaflets, several of which were published during the war are now brought up to date and published as a bound volume.

Much of the information and detail is directed to the progressive nurseryman in England and not applicable to East African conditions. On the other hand, with improvization and a little originality, we in East Africa could improve enormously our nursery practice by following more closely the type of work done at John Innes.

The leaflet on Soil Sterilization is most informative and practical and many growers in East Africa would be well repaid for the extra trouble and expense involved in using sterilized soil for the seed boxes and propagating frames, etc. The leaflet on growing tomatoes out of doors mentions the practice of roguing. This must be carried out if good results are to be obtained, especially so in East Africa, where so many people "save a few odd tomatoes for seed next year". The leaflet "Growing Pure Seed" is interesting, but the subject of growing crops for seed is far too vast and specialized for the leaflet to be anything but readable matter, except to the person well read and up to date on the subject. Much the same applies to the leaflet "Making New Plants: The Colchicine Method".

This book certainly makes one realize that the English nurseryman and keen amateur strive continually to grow their plants to perfection, whilst we in East Africa are very apt to "try our hand" and keep those plants which happen to grow! The book is well worth 3s. 6d. and is a pleasant introduction to those who are not familiar with the fine work John Innes continues to render the horticultural world.

W.B.M.

TOMATO BLIGHT IN KENYA

By R. M. Nattrass, Department of Agriculture, Kenya

(*Received for publication on 4th November, 1949*)

The appearance of the potato blight (*Phytophthora infestans*) in Kenya in 1940 struck a serious blow to the potato crop. In a wet season damage can be severe, especially among the more susceptible varieties. The loss which may ensue is dependent, to a great extent, on the state of the crop when the attack develops. As the tops are mainly affected, total loss of crop rarely follows unless severe blight attacks them before marketable tubers are formed.

As is well known, the same fungus is responsible for the tomato blight. Here, however, the position is different as not only is the foliage affected but the crop being above ground is equally subject to attack. A late attack of blight on potatoes may destroy the tops, but the tubers, being protected by the soil, are not necessarily affected. The tomato crop, on the other hand, is exposed from the earliest stages of fruit development. Once the disease appears unless very prompt measures are taken, the whole of the crop is likely to be destroyed or rendered worthless.

Tomato blight was first recorded in East Africa by Wallace (1944) and described by Wallace and Wallace (1945) by which time the disease was already widespread in the Kilimanjaro and Usambara Districts of Tanganyika. In the Highlands of Kenya, where the tomato is developing into a commercial crop of some importance, blight now occurs wherever it is grown.

As with the potato, the occurrence and severity of tomato blight is almost entirely dependent on the weather. Crops raised during dry periods under irrigation may escape the disease altogether. On the other hand, dull overcast weather, with intermittent rain and a high humidity persisting for much of the twenty-four hours, favours an outbreak. A continuation of these conditions do not, in Kenya, appear to be necessary for the progress of the disease. Heavy dews with drier periods during the day enable the fungus to make headway. An early attack may, however, clear up if sunny weather and low humidity prevail.

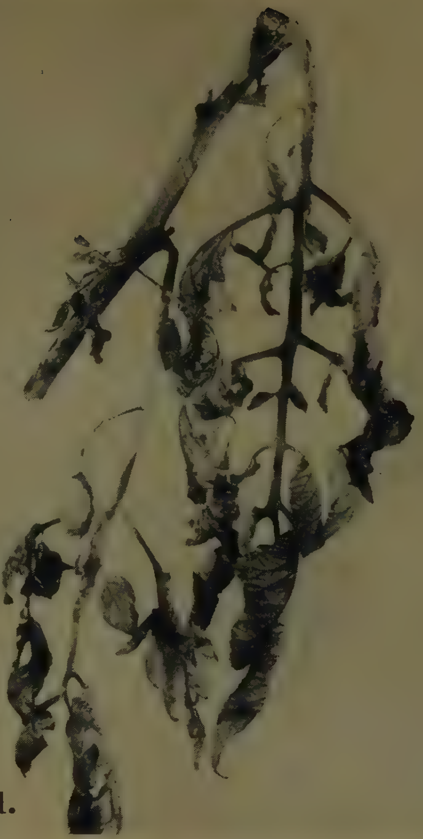
Blight on tomatoes can easily be recognized. The symptoms on the foliage and stems closely resemble those on the potato. Unlike other tomato leaf diseases it does not form small sharply defined round or angular spots. The first signs usually occur on the leaves and stems. On the leaves, a greyish-green area develops. This quickly enlarges, turning brown but retaining the grey-green outer margin. When wet, the diseased part becomes black and soft. Near the edge of the brown part, a faint white mould of the fungus can be seen on the under surface. This mould is most distinct in the early morning. If dry weather follows, the diseased part of the leaf dries up and curls inwards.

The stems, petioles and flower stalks are likewise attacked. On the stems there is no collapse of the tissue but long pale brown or chocolate coloured areas, often encircling the stem, occur and may extend up laterals and leaf stalks causing the leaves to wither. Alternatively, the fungus having attacked a leaf may extend downwards from it into the main stem, or the growing point or flower truss may be destroyed. Fruits are attacked at any stage of growth. The first signs are small, watersoaked patches which, although more often seen around the stalk and, may appear anywhere on the fruit, not infrequently where two fruits on the truss touch each other. The diseased areas extend in size rapidly, becoming brown in colour with mottled or cloudy outlines but the flesh remains firm.

However much the weather may favour the disease, the crop will not become infected unless there are already affected plants of either tomato or potato within a certain distance. It seems most likely that the disease starts in the potato crop where infected tubers give rise to shoots producing spores, which can be carried a considerable distance by wind currents as is shown by the rapid spread of potato blight through East Africa after its first appearance. At the higher altitudes infected potatoes are probably never very far away during the rains. The disease may also be carried into the field or garden with already infected plants from the seed bed. The fungus does not survive on crop debris of the tomato nor does the soil become contaminated. An outbreak may well be started off by volunteer potato plants, either in fields and gardens, or those from tubers thrown

TOMATO BLIGHT IN KENYA

1.



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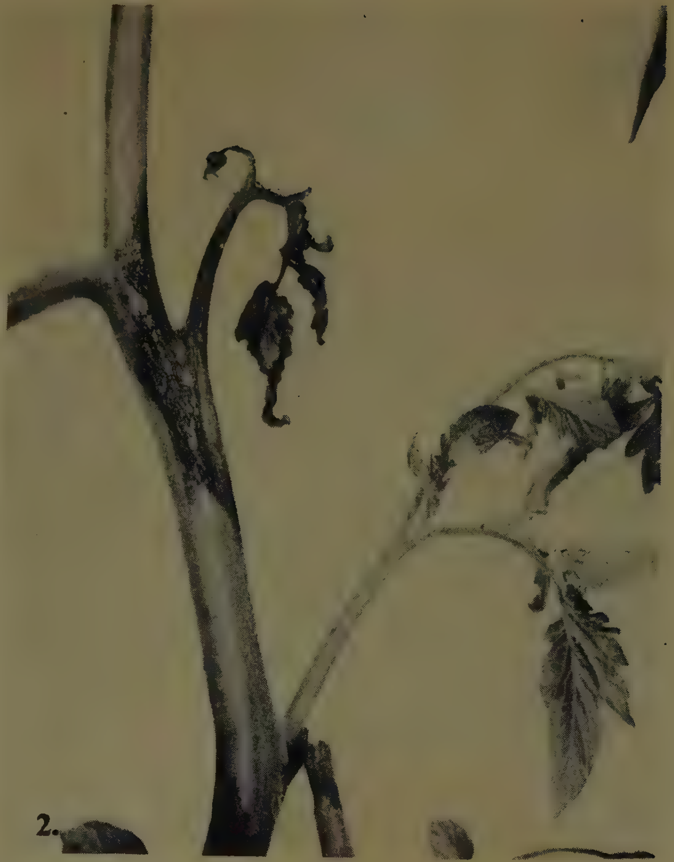
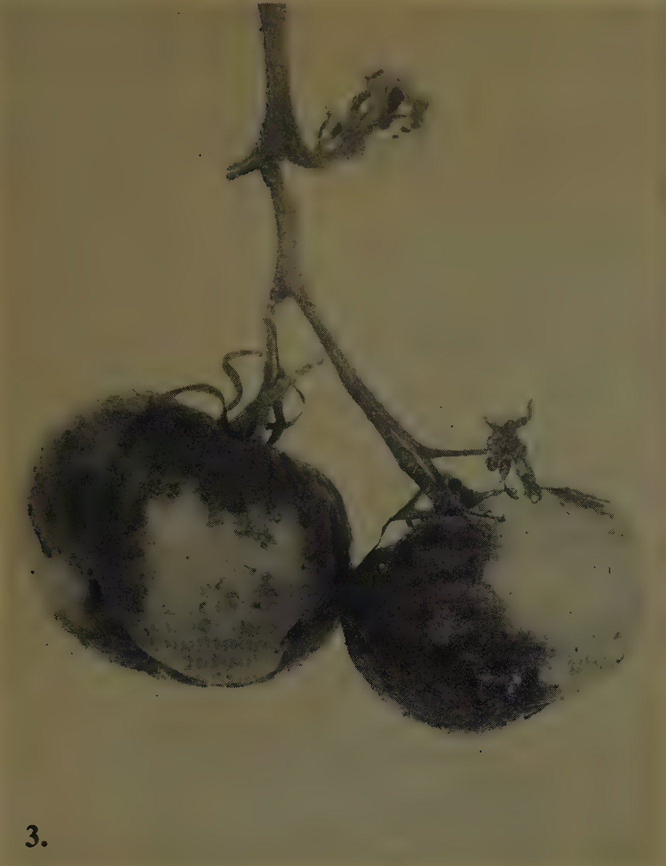


Fig. 1—Tomato leaves heavily attacked by blight, showing collapse of the petiole and in-rolling of the leaflets.

Fig. 2—Early infection of blight on the stem.



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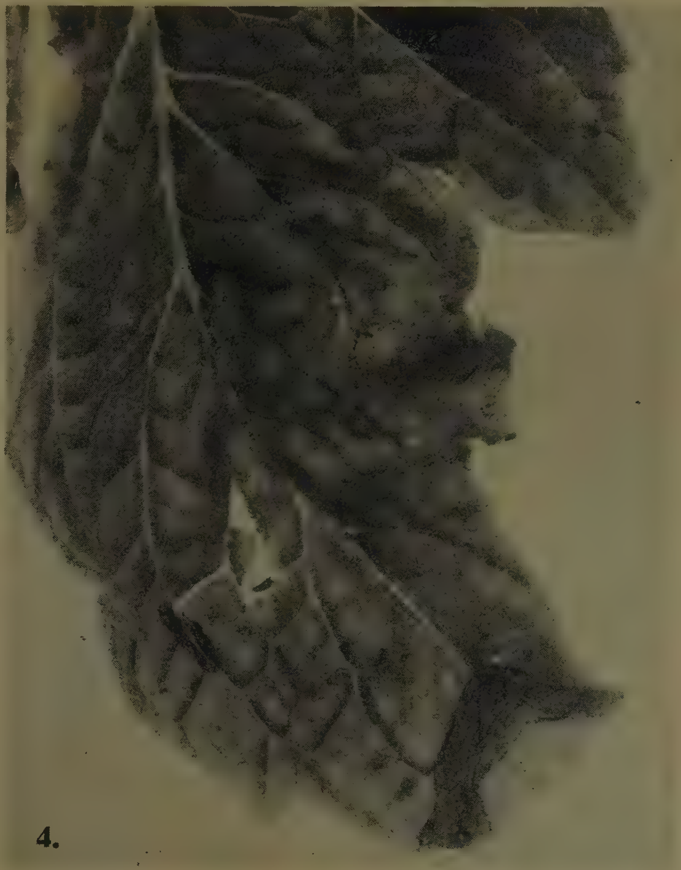

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FIG. 3—Tomato fruits attacked by blight.

FIG. 4—Leaf of tomato showing first signs of attack by blight.

out on to the rubbish heap. Tomatoes that follow potatoes on the same land, or which are grown in close proximity to potatoes, are likely therefore to be attacked early in a blight season. It is, however, doubtful if either of these factors makes much difference once the blight becomes general.

Staking and spacing the plants is an important measure of control. When crowded, unsupported, and unpruned, the plants remain moist longer after dew or rain and are thus longer exposed to infection. If already infected, these conditions encourage the production of spores and consequent spread of the disease. A suitable form of support also enables sprays and dusts to be applied to all parts of the plant.

Blight can be controlled by the application of copper fungicides. Bordeaux Mixture containing 4 lb. of copper sulphate, 5 lb. of hydrated lime to 50 gallons of water (4 oz. of copper sulphate, 5 oz. of hydrated lime to 3 gallons of water) is a suitable spray: other mixtures containing less lime are also used. It is not likely to scorch the foliage but leaves a deposit which will need to be removed from the fruit after picking. Burgundy Mixture, in which the lime is replaced by 2½ lb. of Magadi Household Soda (2½ oz. to make 3 gallons) leaves a thinner deposit, but will cause a certain amount of scorching of the small leaflets. Proprietary fungicides of cuprous oxide or copper oxychloride, such as Perenox, Blitox, Coppesan, etc., can be recommended, as they require only to be added to the requisite quantity of water, usually incorporate a wetter or spreader and are safe to use on the younger foliage. It is an advantage to add to the spray fluids a dispersible sulphur at the rate of 1½ to 2 lb. to 50 gallons (¼ oz. to 3 gallons). The addition will help to control other fungi and to check red spider and Thrips.

If the rains are on, the first spraying should be given in the seed bed, or the young plants can be dipped in the fungicide at the time of planting out. If Bordeaux or Burgundy is used for either treatment of the seedling plants, half the above strength should be used. Spraying should be done every 10–14 days if wet and after heavy rain, otherwise the first spraying can be delayed until the wet weather sets in.

With spraying, the better the cover the more efficient protection the spray is likely to give and within limits the higher the pressure the better the cover. For the larger plantations, a machine capable of delivering at least 60 lb. pressure is needed. For small gardens, a knapsack or bucket pump is all that is likely to be available. With these, more careful application is necessary. With only a watering can, garden syringe or A.R.P. pump, advantage can be taken of dew (Nattrass 1945). Drops of spray fluid alighting on leaf or stem cause the dew drops to coalesce, thus forming an even film with which the fungicide is mixed. The consequent dilution can be compensated for by using rather less water in the spray mixture.

Some control of blight can be obtained by dusting instead of spraying. Proprietary copper dusts are on the market and they can be applied with the minimum of trouble. More frequent applications are required but the general opinion is that dusts are less effective than the liquid fungicides.

Of importance to growers who supply distant markets is that the fruits, when picked, may already be infected although showing no sign of the disease which will then develop during storage or in transit. When blight is known to be present in the crop, fruits, provided they are not dead ripe, are best held in store for a few days and then picked over.

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A LIST OF WEEDS OF THE KENYA HIGHLANDS

By A. V. Bogdan, Pasture Research Officer, Department of Agriculture, Kenya

(*Received for publication on 20th October, 1949*)

In 1948 I undertook, on behalf of the East African Agriculture and Forestry Research Organization, a preliminary survey of the weeds in the experimental plots of the Highland Fertilizer Scheme in order to discover, if possible, indicators of the mineral content of the soil. The material obtained has been handed over for statistical analysis to the officers concerned. During this work some general information on the weed flora was also obtained. The present paper presents this information which is confined to the composition of the weed flora and the distribution of the weeds; the practical questions of weed control are not considered. It is hoped, however, that the information on distribution and relative importance of the local weeds may prove useful for subsequent work on weed control.

In the course of the survey, which was carried out in June and August–September, 1948, 43 farms in the Kitale, Eldoret, Ol Kalou and Nakuru–Njoro regions were visited and the weeds of the experimental plots, and also in many cases those of the adjacent fields, were recorded. All the observations were confined to the weeds of maize and wheat.

Number of Species

Altogether 123 species have been recorded from the experimental plots and fields examined. Out of this number 35 species proved to be plants which, being components of the local indigenous flora, are only occasionally encountered in the maize and wheat fields, mostly in places of recently started cultivation. These 35 species cannot be regarded as weeds and they are not mentioned further. The remaining 88 species as a rule follow the cultivation, though some of them (e.g. African Couch grass—*Digitaria abyssinica*, *Cyperus rigidifolius*, etc.) are also permanent components of the natural or semi-natural vegetation. Of these 88 species about 30 species are of considerable importance; the remaining 60 species are less important, though some of them are either widely distributed or of importance in localized areas or even individual farms.

Geographical Types of Weeds

According to their origin all our weeds can be divided into three groups—(1) weeds of European origin or temperate zone in general, (2) weeds of tropical or sub-tropical origin now widely distributed throughout the warm countries, and (3) local African weeds.

Weeds of European Origin.—Of the European weeds a few species (*Avena fatua, Stellaria media, Raphanus raphanistrum, Raphanus sativus*) have been met with only in localized areas or on individual farms. Some of them (*Avena, Raphanus*) represent a definite danger as potential noxious weeds. A group of European (and also Mediterranean) weeds is more prevalent. These weeds are already widely distributed in the Kenya Highlands and they probably entered the country much earlier than those occurring in limited isolated areas. Many of these species are now widely distributed all over the world. Our more important weeds of this group are:—

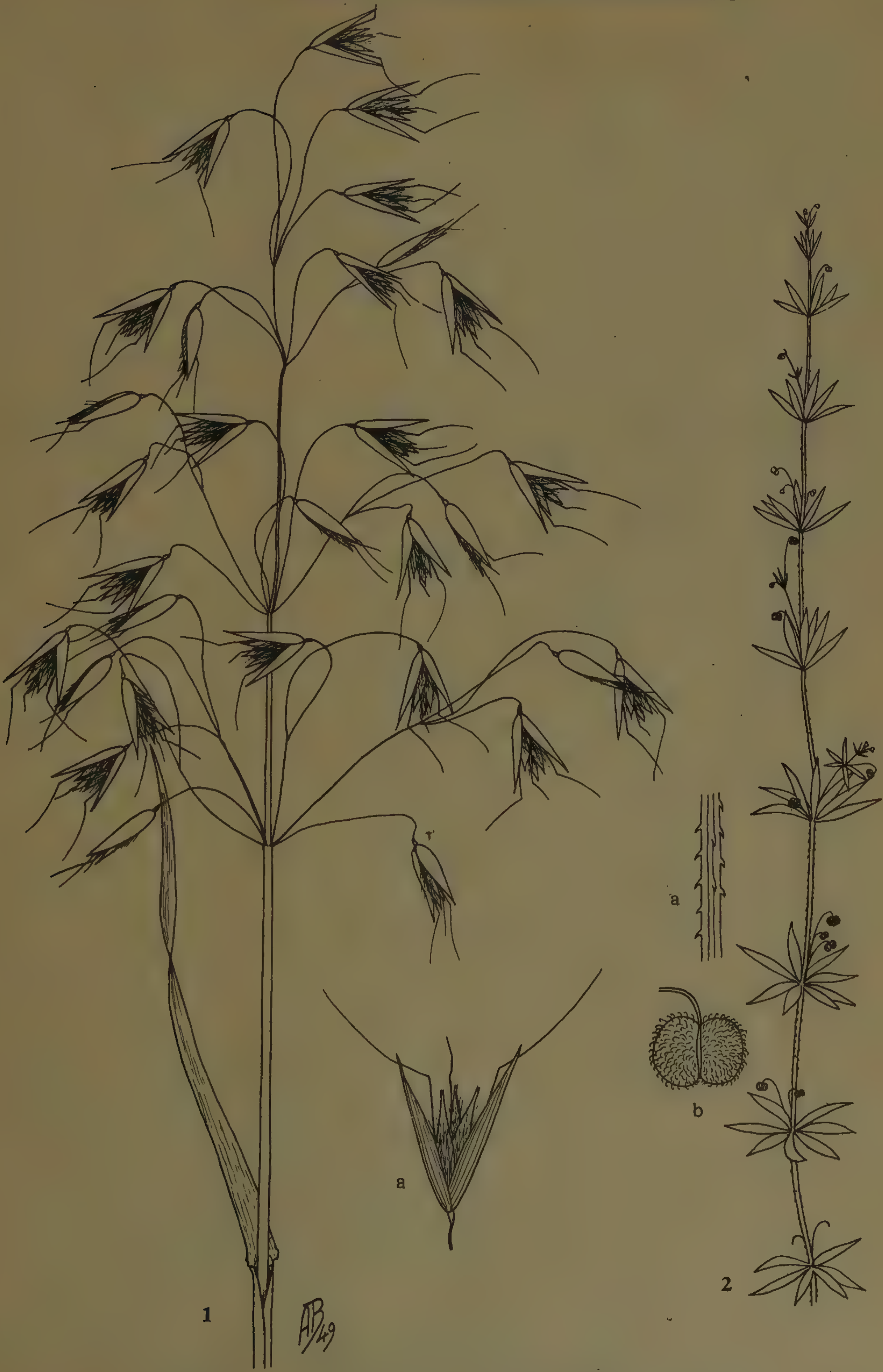
Polygonum convolvulus,
Galium aparine,
Lolium temulentum,
Silene gallica,
Brassica campestris,
Chenopodium album,
Chenopodium murale,
Spergula arvensis,
Corrigiola litoralis.

All the weeds of European origin are annuals. They mostly occur and are of importance in the cooler areas at high altitudes.

Weeds of Tropical (or Sub-tropical) Origin, which are now widely distributed all over the warm countries, are particularly numerous and of great importance in the area surveyed. The main species of this group are:—

Targetes minuta,
Bidens pilosa,
Commelina benghalensis,
Galinsoga parviflora,
Digitaria horizontalis,
Eleusine indica,
Cyperus rotundus,
Leucas martinicensis.

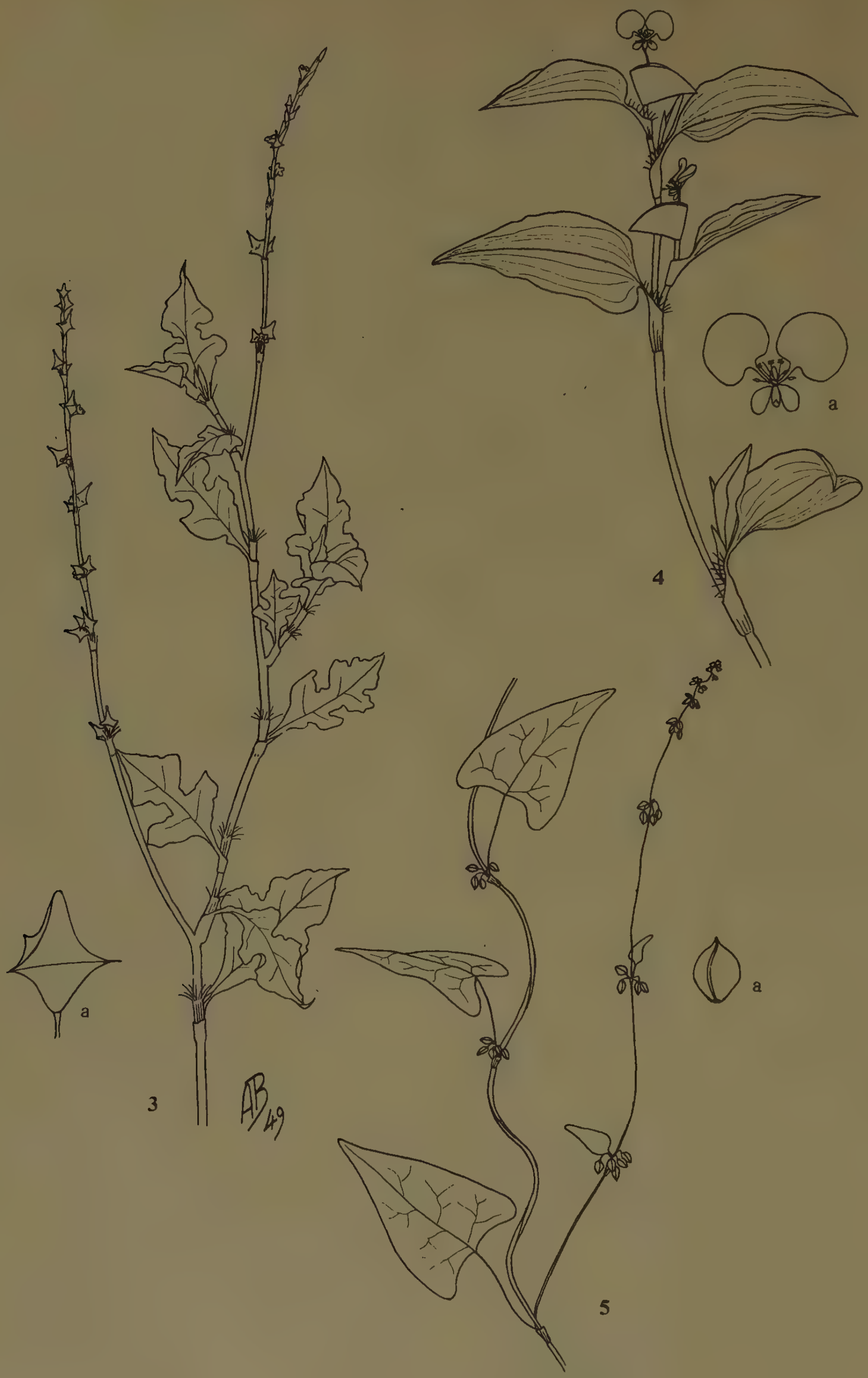
Amaranthus tricolor probably also belongs to this group. Nearly all weeds of the group are annuals. Among the important weeds only



HALF-SIZE, 1A NATURAL, 2A AND 2B, LARGER THAN NATURAL

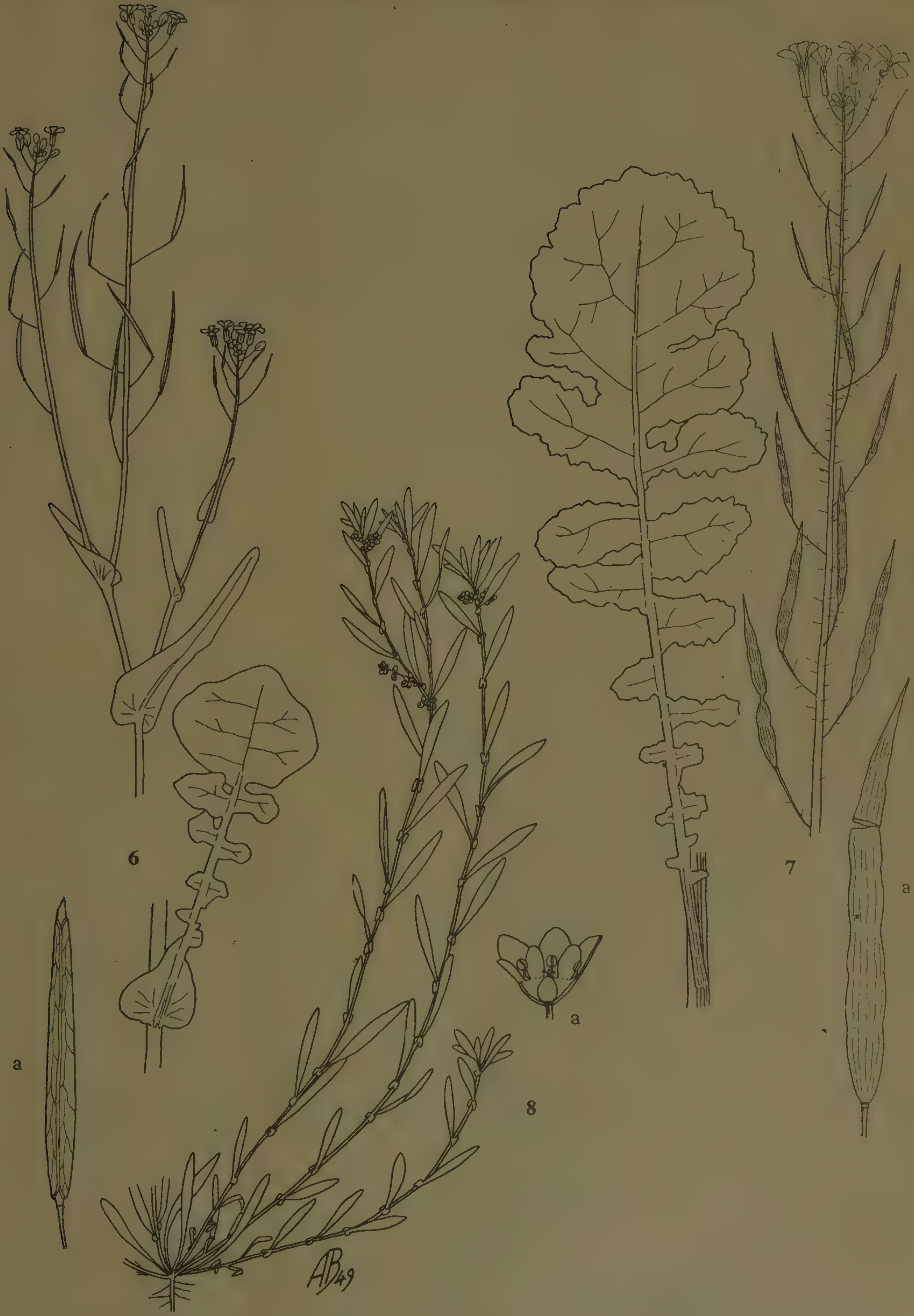
FIG. 1—*Avena fatua* L. (s.l.) Wild Oat. (*a*) Spikelet.

FIG. 2—*Galium aparine* L. Cleavers. (*a*) Portion of stem.
(*b*) Fruit.



Half-Size **Detail Larger than Natural**

Fig. 3—*Oxygonum atriplicifolium* Marb. Double thorn. (*a*) Fruit.
Fig. 4—*Commelina benghalensis* L. (*a*) Flower.
Fig. 5—*Polygonum convolvulus* L. Black Bindweed. (*a*) Fruit.

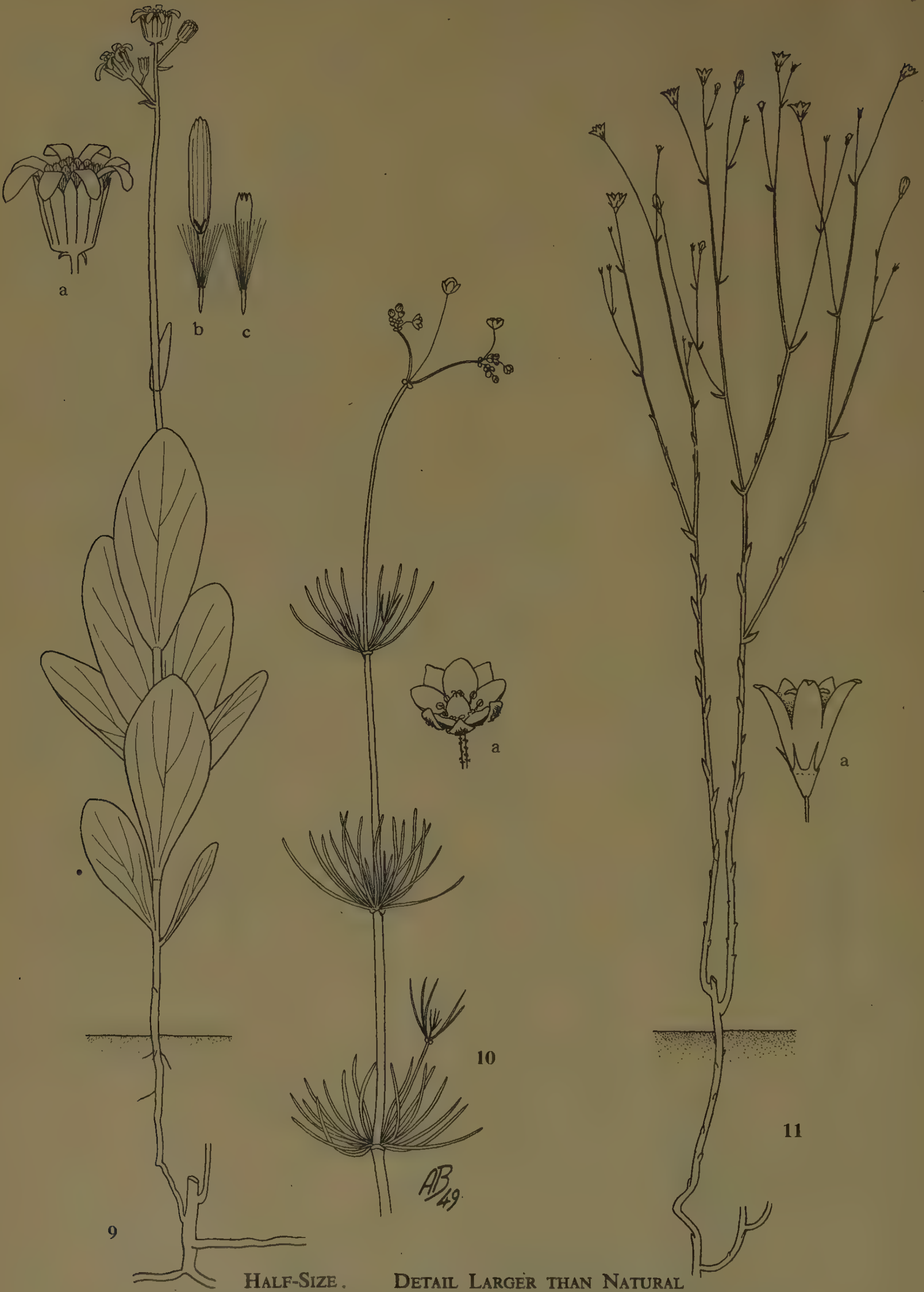


HALF-SIZE. FRUITS 1A AND 2A, NATURAL, 3A LARGER THAN NATURAL

FIG. 6—*Brassica campestris* L. Charlock. (*a*) Fruit.

FIG. 7—*Raphanus raphanistrum* L. Jointed Charlock. (*a*) Fruit.

FIG. 8—*Corrigiola litoralis* L. Strapwort. (*a*) Flower.



HALF-SIZE. DETAIL LARGER THAN NATURAL

FIG. 9—*Senecio ruwenzoriensis* S. Moore. (*a*) Flower-head; (*b*) Ray-floret; (*c*) Disk-floret.

FIG. 10—*Spergula arvensis* L. Spurrey. (*a*) Flower

FIG. 11—*Wahlenbergia virgata* Engl. (*a*) Flower.

Cyperus rotundus is a perennial; it is a sedge spreading by means of rhizomes. This species, being also a member of the indigenous flora of Kenya, has probably come into cultivation not via the seed of cultivated plants but from the natural vegetation.

Local African Weeds are confined to the African continent or even to East Africa. This group is very numerous in species, but with a few exceptions it consists of comparatively unimportant weeds. The main weeds of the group are:—

Digitaria abyssinica,
Oxygonum atriplicifolium,
Brassica schimperi,
Monsonia biflora,
Cyperus rigidifolius,
Gynura crepidioides,
Guizotia oblonga,
Wahlenbergia virgata,
Senecio ruwenzoriensis,
Gladiolus quartinianus,

In this group the proportion of perennials is fairly high and nearly all types of perennial weeds are represented. Bulbiferous perennial weeds, weeds with rhizomes and weeds with spreading, deep rootstocks are encountered among the local African species.

Regions of the Weed Flora

As has already been mentioned, the survey was carried out in the Kitale (Trans Nzoia), Eldoret (Uasin Gishu plateau), Ol Kalou and Njoro–Nakuru regions. In these regions the weed flora shows distinct differences which can best be seen from the lists of the ten commonest weeds of each region. In these lists the main weeds are placed in order of their relative abundance. As all the observations were confined to the year 1948 and the abundance of the main weeds may vary considerably from year to year depending on the weather, the lists given below are only of relative certainty.

Kitale (Trans Nzoia) Region.

Ten main weeds of this region in order of their relative abundance are:—

Galinsoga parviflora,
Bidens pilosa,
Tagetes minuta,
Commelina benghalensis,
Digitaria horizontalis,
Amaranthus tricolor,
Eleusine indica,
Digitaria abyssinica,
Paspalum commersonii,
Gladiolus quartinianus.

Cyperus rotundus, Datura stramonium, Chloris pycnothrix, Portulaca oleracea and *Eragrostis deckindtii,* though not encountered among the most important weeds, are fairly characteristic of the region. The last three species are more important as weeds at the lower altitudes. The seven most important weeds of this region belong to the same geographical type, i.e. cosmopolitans of tropical origin (*Amaranthus tricolor* is provisionally considered as belonging to this group). The less important weeds belong to different geographical types.

Eldoret (Uasin Gishu Plateau) Region.

On the Uasin Gishu plateau the ten most abundant weeds are:—

Tagetes minuta,
Bidens pilosa,
Chenopodium album,
Oxygonum atriplicifolium,
Amaranthus tricolor,
Oxalis abyssinica(?),
Brassica schimperi,
Polygonum convolvulus,
Corrigiola litoralis,
Silene gallica.

Among the less important weeds the following species are characteristic of the region:—

Monsonia biflora,
Caylusea abyssinica,
Lolium temulentum,
Spergula arvensis,
Wahlenbergia virgata,
Guizotia oblonga.

Of the ten most important weeds of the region only three species belong to the cosmopolitan tropical weeds. The rest are either European or local African species. Some moderately important weeds of the Uasin Gishu plateau are characteristic of fairly poor soil; the presence of *Amaranthus tricolor* (which prefers better soil) in the list of the ten main weeds may be explained by the fact that this species was very abundant near Kipkabus where the soil is better and where the weed flora differs considerably from that of the central part of the plateau. However, only two farms were examined near Kipkabus, and the information is insufficient to consider this small area separately. *Avena fatua* (Wild Oat) was met with as a rather abundant weed in the Kipkabus area. It appears that this weed has only recently come into Kenya.

Ol Kalou Region.

The weed flora of this region is very characteristic and, therefore, the region is dealt with separately though only a few farms were visited. The ten main weeds of the region are as follows:—

Amaranthus tricolor,
Chenopodium murale,
Galium aparine,
Brassica campestris,
Cyperus rigidifolius
Malva verticillata,
Solanum nigrum,
Stellaria media,
Galinsoga parviflora,
Oxalis corniculata.

Among less important weeds *Corrigiola litoralis, Polygonum convolvulus, Wahlenbergia virgata* and *Senecio ruwenzoriensis* are also common. A large proportion of European weeds is a characteristic feature of the region.

Njoro–Nakuru Region.

The ten main weeds of the region are as follows:—

Tagetes minuta,
Amaranthus tricolor,
Bidens pilosa,
Galinsoga parviflora,
Polygonum convolvulus,
Chenopodium botrys,
Digitaria ternata,
Chenopodium album,
Datura stramonium,
Eleusine indica.

Of less abundant weeds *Setaria pallidifusca, Raphanus raphanistrum, Raphanus sativus* and *Gutenbergia ruepellii* are characteristic here. *Raphanus raphanistrum* and *Raphanus sativus,* which occupy a somewhat limited area, appear in masses and become noxious, though, probably, they are also recent arrivals in the country. Although the four first species in the list of main weeds belong to the cosmopolitan tropical weeds, those of European origin are also well represented in the region. The weeds characteristic of better soils are numerous here.

LIST OF THE WEEDS

Amaranthus blitum L. (*Amaranthaceæ*).—Prostrate annual herb. Occasionally occurs in Eldoret region.

Amaranthus tricolor L. Pigweed.—Erect annual herb. Very common throughout the whole area, particularly in Njoro–Nakuru and Ol Kalou regions. Apparently prefers good soil.

Anagallis arvensis L. Pimpernel (*Primulaceæ*).—Small, slender annual herb. Rather harmless as a weed. Occasional in Eldoret region.

Avena fatua L. (s.l.). Wild Oat (*Gramineæ*).—Tall annual grass. Met with near Kipkabus where it is abundant on some farms. Noxious weed in many countries. (Fig. 1.)

Bidens pilosa L. Black Jack (*Compositæ*).—Annual herb. One of the most common weeds. Frequent and abundant everywhere, particularly in Kitale region. Less frequent in Ol Kalou region.

Borreria filitula K. Schum. (*Rubiaceæ*).—Small annual herb. Fairly frequent but not numerous in Kitale region where it occurs mainly in new land. Harmless as a weed.

Brachiaria semiundulata Stapf (*Graminaæ*).—Small annual grass, harmless in fields. Occurs throughout the area except in Ol Kalou region.

Brassica campestris L. Charlock (*Cruciferæ*).—Large annual or biennial herb. Frequent in the whole area. Sometimes numerous and then troublesome. (Fig. 6.)

Brassica schimperi Boiss.—Annual herb. Occurs frequently and is often numerous except in Kitale region, where it is fairly rare.

Bulbostylis schimperiana C. B. Cl. (*Cyperaceæ*).—Tiny annual sedge. Occurs mostly on waterlogged, badly drained ground. Rather harmless as a weed though often appears in masses.

Capsella bursa pastoris Moench. Shepherd's Purse (*Cruciferæ*).—Annual herb. Met with near Kipkabus and also near Timboroa. Common weed in Europe.

Caylusea abyssinica Fisch. (*Resedaceæ*).—Annual erect herb. Fairly frequent in Eldoret region.

Chenopodium album L. Goosefoot (*Chenopodiaceæ*).—Tall annual herb. Frequent and numerous in the whole area, particularly in Eldoret region. One of the commonest weeds though not very troublesome.

Chenopodium botrys L.—Annual erect herb. Frequent in the whole area, though comparatively unimportant.

Chenopodium murale L.—Annual erect herb. Frequent in Ol Kalou region where it is one of the main weeds. Also occurs in Eldoret region.

Chenopodium sp.—Small annual prostrate herb. Occurs occasionally in fields, mostly in Kitale and Eldoret regions. Harmless as a weed.

Chloris pycnothrix Trin. False Star Grass (*Gramineæ*).—Annual grass prostrate at the base. Occurs frequently except in Ol Kalou region. Fairly harmless in the area surveyed. More common as a weed at lower altitudes.

Commelina africana L. (*Commelinaceæ*).—Annual or perennial prostrate herb. Occurs occasionally in fields, mostly at higher altitudes. Not important.

Commelina benghalensis L.—Annual or sometimes perennial herb with stems prostrate at the base. Very common and numerous in Kitale region where it is one of the most important weeds. Less numerous in other regions. (Fig. 4.)

Commelina nodiflora L.(?).—A herb somewhat similar to *Commelina benghalensis*. Occurs occasionally in Kitale area. More common as a weed at lower altitudes.

Commelina subulata Roth.—Small annual herb with narrow fleshy leaves. Occurs in fields in Kitale region mostly on badly drained soil. Sometimes abundant in such places. Of little importance as a weed.

Corrigiola litoralis L. Strapwort (*Caryophyllaceæ*).—Annual prostrate or sub-erect herb. Occurs in Eldoret, Ol Kalou and Njoro–Nakuru regions. Occasionally appears in masses and is then a fairly troublesome weed. (Fig. 8.)

Crambe kilimandscharica O. Schulz.(?) (*Cruciferæ*).—Annual herb. Met with in a field in Ol Kalou region. (A fairly common weed near Elmenteita.)

Crotalaria incana L. (*Leguminosæ*).—Occasional in Eldoret and Njoro–Nakuru regions.

Cynodon dactylon Pers. Star Grass (*Gramineæ*).—Perennial grass with spreading and rooting stolons. Occurs in fields in Kitale region. Not of great importance as a weed in this area.

Cynoglossum geometricum Baker and Wright (*Boraginaceæ*).—Annual or biennial herb. Occasional in Kitale, Eldoret and Njoro–Nakuru regions. Sometimes fairly abundant and then troublesome.

Cyperus rigidifolius Steud. Nut Grass (*Cyperaceæ*).—Perennial sedge with underground rhizomes. Sometimes occurs in fields as a troublesome weed, mostly in Eldoret and Ol Kalou regions.

Cyperus rotundus L. Nut Grass.—Perennial sedge spreading by means of rhizomes. Occurs mostly in fields of Kitale region. Sometimes abundant and then troublesome.

Datura stramonium L. (*Solanaceæ*).—Large annual herb with spiny fruits. Though declared a noxious weed subject to compulsory control the plant is frequent in the whole area (except probably in the Ol Kalou region). It is, however, only seldom abundant in field crops.

Digitaria abyssinica Stapf. African Couch Grass (*Gramineæ*).—Perennial grass spreading by means of underground rhizomes. Frequent throughout the area and particularly in Kitale region where it is fairly abundant. A troublesome weed which is difficult to control.

Digitaria horizontalis Willd.—Annual grass. Frequent and abundant in Kitale region. Also occurs in Eldoret and Njoro–Nakuru regions.

Digitaria ternata Stapf.—Annual grass. Frequent and abundant in Eldoret and Njoro–Nakuru regions. Also occurs in Kitale region.

Echinochloa colona Link. (*Gramineæ*).—Annual grass. Met with in quantity in a field near Kapsabet.

Eleusine indica Gaertn. (*Gramineæ*).—Annual grass. Very common and numerous in Kitale and Njoro-Nakuru regions.

Eleusine multiflora Hochst.—Annual grass. Sometimes occurs in fields with better soil in Eldoret and Ol Kalou regions.

Eragrostis chalcantha Trin. (*Gramineæ*).—Annual or occasionally perennial small grass. Occurs frequently at higher altitudes. Not important as a weed.

Eragrostis cilianensis Link.—Annual grass. Occurs occasionally in fields in Kitale and Eldoret regions. More common as as weed at lower altitudes.

Eragrostis deckindtii Pilger.—Annual grass. Occurs in Kitale region. More common as a weed at lower altitudes.

Eragrostis densa De Wild.—Annual slender grass. Met with in a field near Kapsabet.

Eragrostis kiwuensis Jedw.—Small annual grass. Occurs in Njoro–Nakuru and Eldoret regions. Not important as a weed.

Eragrostis tenuifolia Hochst. Annual grass. Occurs in fields in Kitale and Eldoret regions. More common as a weed at lower altitudes.

Euphorbia sanguinea Hochst. and Steud. Prostrate Spurge (*Euphorbiaceæ*).—Low-spreading annual herb. Occurs in Kitale and Eldoret regions. Harmless as a weed.

Galinsoga parviflora Cav. Macdonaldii (*Compositæ*).—Annual herb. Frequent throughout the whole area. Particularly common and abundant in Kitale and Njoro–Nakuru regions. Apparently prefers better soil.

Galium aparine L. Cleavers (*Rubiaceæ*).—Annual trailing herb with adhering stems. Occurs at altitudes over 7,500 ft. in Ol Kalou, Eldoret (near Kipkabus) and Njoro–Nakuru regions. Met with only on a few farms where it is, however, abundant and troublesome, causing the lodging of the crop. (Fig. 2.)

Geranium simense Hochst. (and allied species) Crane's Bill (*Geraniaceæ*).—Annual herb. Common weed in Ol Kalou region. Also occurs in Eldoret and Kitale regions above 7,000 ft. altitude.

Gladiolus quartinianus A. Rich. Corn Flag (*Iridaceæ*).—Perennial tuberous herb with grass-like leaves. Occurs frequently in fields in Kitale region, mostly in new land. Fairly harmless as a weed.

Gnaphalium undulatum L. Cudweed (*Compositæ*).—Annual herb with white, hairy leaves. Met with in Ol Kalou region.

Gomphrena celsioides Mart. (*Compositæ*).—Perennial low herb with underground spreading rootstocks. Met with in a field in Kitale region. A fairly common weed at lower altitudes.

Guizotia oblonga Hutch. (*Compositæ*).—Annual herb. Met with in a few fields in Njoro–Nakuru and Eldoret regions. Fairly abundant in these fields.

Gutenbergia ruepellii Sch. Bip. (*Compositæ*).—Annual herb. Occurs in Eldoret region where it is abundant in localized areas.

Gynura crepidioides Benth. (*Compositæ*).—Annual herb. A fairly common weed in Njoro–Nakuru and Eldoret regions.

Hibiscus trionum L. (*Malvaceæ*).—Annual herb. Frequent though not abundant in Kitale and Eldoret regions.

Imperata cylindrica Beauv. Alang-Alang (*Gramineæ*).—Perennial grass with stout rhizomes. Met with in Kitale region at roadside. Noxious weed in many warm countries.

Ipomoea hardwickii Hemsl. (*Convolvulaceæ*).—Annual(?) spreading herb. Met with in quantity on a farm in Eldoret region.

Leucas martinicensis R. Br. (*Labiatæ*).—Annual erect herb. Frequent and often abundant, but not very troublesome in Njoro–Nakuru, Eldoret and Kitale regions.

Lolium temulentum L. Darnel (*Gramineæ*).—Annual grass. This noxious weed is fairly common in Eldoret region. It also occurs in Nakuru–Njoro region.

Malva verticillata L. Mallow (*Malvaceæ*).—Annual herb. Frequent in Ol Kalou region and also occurs in Eldoret region.

Monsonia biflora D.C. (*Geraniaceæ*).—Annual herb. Common, though not very troublesome, weed in Eldoret region. It usually occurs on poor soil.

Nicandra physaloides Gaertn. Chinese Lanterne (*Solanaceæ*).—Large annual herb. Occurs in Kitale and Njoro–Nakuru regions, usually on rich soil.

Oxalis abyssinica Turcz.(?) (*Oxalidaceæ*).—Small perennial herb with numerous small underground tubers. Common and numerous weed in Kitale and Eldoret regions. Also occurs in Ol Kalou and Njoro–Nakuru regions.

Oxalis corniculata L.—Annual herb often with creeping and rooting stems. Occasional in the whole area, mostly at higher altitudes. Said to be a bad weed of *Pyrethrum*.

Oxygonum atriplicifolium Marb. Double Thorn (*Polygonaceæ*).—Very common and abundant weed in Eldoret region. Also occurs in Kitale region. (Fig. 3.)

Paspalum commersonii Lam. (*Gramineæ*).—Annual or perennial grass. Occurs frequently in fields of Kitale and Njoro–Nakuru regions. Sometimes abundant, particularly on wet ground.

Pennisetum clandestinum Hochst. Kikuyu Grass (*Gramineæ*).—Perennial grass spreading by means of rooting stolons and rhizomes. Occurs fairly frequently in fields in Ol Kalou, Nakuru–Njoro and Eldoret regions.

Polygonum convolvulus L. Black Bindweed (*Polygonaceæ*).—Annual twining herb. Frequent throughout the whole area and often abundant in Njoro–Nakuru and Eldoret regions. A troublesome weed which, when abundant, causes the lodging of wheat. (Fig. 5.)

Portulaca oleracea L. Purslane (*Portulacaceæ*).—Prostrate annual herb with fleshy leaves. Occasional, mostly in Kitale region. Not important as a weed under field conditions. Common weed in gardens.

Raphanus raphanistrum L. Jointed Charlock (*Cruciferæ*).—Annual or biennial herb. Abundant in a limited area north-east of Nakuru. Troublesome weed. (Fig. 7.)

Raphanus sativus L.(?) Wild Radish.—Annual or biennial herb very similar to the previous species. Frequent in a limited area north-east of Nakuru.

Rhynchelytrum roseum Stapf and Hubbard. Natal Grass (*Gramineæ*).—Annual or short-lived perennial tufted grass. Sometimes invades new land in Kitale region. More common as a weed in perennial crops.

Schkuria isopappa Benth. (*Compositæ*).—Small slender annual herb. Met with in fields in Eldoret region.

Senecio discifolius Oliv. Groundsel (*Compositæ*).—Annual herb. Occurs frequently in Eldoret, Kitale and Njoro–Nakuru regions. Fairly harmless as a weed.

Senecio ruwenzoriensis S. Moore.—Perennial herb with deep-spreading rootstocks. A potentially noxious weed though only seldom encountered in fields (Ol Kalou, Eldoret and Kitale regions). Poisonous. (Fig. 9.)

Setaria pallidifusca Stapf and Hubbard (*Gramineæ*).—Annual grass. Frequent in Njoro–Nakuru region.

Setaria verticillata Beauv. Love Grass.—Annual grass with adhering spikes. Found in a field in Kitale region. More common as a weed at lower altitudes.

Silene gallica L. Campion (*Caryophyllaceæ*).—Annual herb. Frequent and sometimes troublesome in Eldoret region and to a lesser extent in Njoro–Nakuru region.

Solanum grossidentatum A. Rich. Nightshade (*Solanaceæ*).—Annual herb. Occasionally found in fields in Eldoret and Kitale regions. Fairly harmless.

Solanum nigrum L. (s.l.) Nightshade.—Annual herb. Frequently found in fields throughout the whole area. Fairly harmless as a weed.

Sonchus exauriculatus Hoffm. Thistle (*Compositæ*).—Perennial herb with spreading rootstocks. Sometimes found in fields in Kitale, Eldoret and Njoro–Nakuru regions. Although not frequent it is potentially troublesome.

Sonchus oleraceus L. (s.l.) Thistle.—Annual herb. Very common throughout the whole area except in Ol Kalou region. Occurs frequently but only rarely abundant. Rather harmless as a weed in this area.

Spergula arvensis L. Spurrey (*Caryophyllaceæ*).—Annual herb. Occurs sometimes in Njoro–Nakuru and Eldoret regions. A very troublesome weed in wheat fields in a limited area near Amobkoi. (Fig. 10.)

Stellaria media Cyrill. Chickweed (*Caryophyllaceæ*).—Annual herb. Met with in quantity on a farm in Ol Kalou region. Common weed in Europe.

Tagetes minuta L. Mexican Marigold (*Compositæ*).—Tall annual herb. The most common and abundant weed in Eldoret, Njoro–Nakuru and Kitale regions. Much less frequent in Ol Kalou region.

Torilis africana Spreng. Bur Parsley (*Umbelliferæ*).—Annual herb. Sometimes found in Eldoret region.

Tribulus terrestris L. Devil's Thorn or Calthrop (*Zygophyllaceæ*).—Annual prostrate herb with spiny fruits. Met with in a field in Eldoret region.

Trifolium johnstoni Oliv. Kenya White Clover (*Leguminosæ*).—Found in a few fields in Njoro-Nakuru and Ol Kalou regions. Rare as a weed.

Tripteris vailantii Decaisne (*Compositæ*).—Perennial herb with spreading rootstock. Found in a few fields (where it was, however, abundant) in Kitale region.

Vigna stuhlmannii Harms. Wild Cow Pea (*Leguminosæ*).—Twining annual herb. Fairly frequent and sometimes abundant in Kitale region. Also occurs in Eldoret region.

Wahlenbergia virgata Engl. (*Campanulaceæ*).—Slender perennial herb with spreading rootstock. Found in a few fields in Ol Kalou and Eldoret regions. Probably a potentially troublesome weed. (Fig. 11.)

ACKNOWLEDGMENTS

Thanks are due to Mr. P. J. Greenway, Systematic Botanist, E.A.A.F.R.O., for identifying some of the weeds, and to members of the Highland Fertilizer Scheme for assistance during the investigation.

A PRELIMINARY TEST OF DRIED CROCODILE MEAT IN THE FEEDING OF PIGS

By **W. P. Bruce, Department of Veterinary Science, Kabete, Kenya**

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During recent years there has been a steady development of the pig and poultry industries in Kenya and a progressive improvement in the quality and class of livestock produced. At the same time the production of available protein concentrate has not kept pace with the demands of the pig and poultry industries and an insufficient quantity of meat and carcass meals is produced. It is therefore necessary to find a suitable substitute for these animal feeds if the higher grade of stock is to be fed in the correct manner and at economical rates.

The crocodile catching industry is developing in East Africa and particularly in Uganda for the overseas sale of crocodile bellies. At the moment the meat and bones from the crocodile carcasses are not salvaged and the object of this test was to find out if dried crocodile meat was a suitable substitute for meat and carcass meals in the production of bacon pigs and also to a ascertain whether or not the feeding of dried crocodile meat produced any taint in the pig carcasses.

It is realized that crocodile meat will be produced in small quantities and in widely scattered localities and that there will be difficulties connected with the drying, collection and transportation of this by-product of the crocodile fishing industry, but it was thought that if crocodile meat could replace meat-meal in pig and poultry rations then these difficulties of transportation and drying could be overcome.

For this preliminary test, arrangements were therefore made for crocodile meat to be dried on the shores of Lake Kioga in the form of small lumps and strips, as is done for biltong. As only a small quantity of dried crocodile meat was available, it was decided to use the paired method of feeding, and the experimental lay-out was to take litter mates, divide at random into pairs, and to weigh them at regular intervals and to record the food consumption for each pair. The basis of rationing was that laid down by French (1942) as a result of his Mpwapwa experiments. Two pigs (Group I) were placed directly on French's ration and were given meat-meal, as suggested by him, through the period from weaning to slaughter. Two further pigs (Group II) were fed dried crocodile meat instead of meat-meal in the ration of Group I, whilst two further pigs (Group III) were fed crocodile meat instead of meat-meal up to a live weight of 120 lb. and then were put on meat-meal rations of Group I until slaughter The objective of this lay-out was—

(*a*) to see if dried crocodile meat could replace meat-meal directly;

(*b*) to see whether it produced a taint if fed continuously from weaning till slaughter; and

(*c*) to see if, in the event of any taint being produced by continuous feeding, this could be removed by feeding meat-meal for the last six to eight weeks of fattening.

The crocodile meat, as received from Uganda, had a rather strong and to some people offensive smell and before it could be incorporated in the rations it was further dried in the sun and then reduced by mincing for easy incorporation with the other constituents of the rations.

The pigs were weighed at weekly intervals and the diets changed at the live weight points suggested by French. The actual details of the rations fed are shown in Table I. A summary of the live weight changes is given in Table II, and it will be observed that some of the pigs lost weight after reaching the 60 lb. live weight mark. This can be attributed to the fact that the supply of dried crocodile meat temporarily failed and, whilst there was no crocodile meat available, the pigs in the other groups were given no meatmeal to make the results comparable. From the time dried crocodile meat and meat-meal feeds were resumed no further serious break occurred in the live weight changes. All the pigs, with the exception of No. 2633, were sent to Uplands Bacon Factory and the factory reports are as follows:—

Group I—Pig No. 2630.

Dressed weight 82.8 per cent.

Conformity and finish poor, but with a fairly firm setting quality.

Pig No. 2631.

Dressed weight 84.97 per cent.

Conformity and finish normal. Setting fairly firm.

Group II—Pig No. 2632.

Dressed weight 86.7 per cent.

Conformity and finish good. Setting quality firm, and described as the best pig of the bunch.

Pig No. 2633.—Killed for pork.

Dressed weight 80.58 per cent.

There was no taint before or after cooking.

Group III—Pig No. 2634.

Dressed weight 83.33 per cent.

Conformity and finish good, Setting fairly firm.

Pig No. 2635.

Dressed weight 80 per cent.

Conformity and finish poor. Setting fairly firm.

All carcasses were examined for taint after cooking and there was no suggestion in any joint or in any carcass that the feeding of dried crocodile meat had produced any unpleasant or any abnormal flavour.

SUMMARY

Although only a limited number of pigs was used, this test suggests that a further study of dried crocodile meat, as a supplement to the deficient supplies of meat-meal, is worthy of consideration. The limited data provided also suggest that crocodile meat is capable of yielding the same rates of growth and carcass quality as meat-meal.

ACKNOWLEDGMENTS

It is with great pleasure that I acknowledge my indebtedness to the Director of Veterinary Services for his permission to carry out this work and to publish the results, to Dr. H. S. Purchase in whose professional care the animals were placed, and to Dr. M. H. French for drawing up the details of the experiment and of the rations and for suggesting the work. I also wish to acknowledge my thanks to the Old East African Trading Company who so kindly arranged for the drying, collection and supplying of the dried crocodile meat.

REFERENCES

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TABLE I

RATIONS FED TO THE THREE GROUPS

Group I.—Pigs fed on Meat-meal as the sole protein.

Live Weights of Pigs	30–60 lb.	60–90 lb.	90–120 lb.	120–150 lb.	150–200 lb.
Maize meal	40	44	46	44	40
Barley meal	20	20	20	25	30
Meat-meal	12·5	8	6	3	2
Bran	25	25	25	25	25
Mineral supplement ..	2·5	3	3	3	3
Period over which this diet was fed	10–6–48 to 28–6–48	29–6–48 to 5–8–48	6–8–48 to 26–8–48	27–8–48 to 16–9–48	17–9–48 to 23–10–48

Group II.—Pigs fed Crocodile meat as the sole protein.

Maize-meal	37	42	44	43	39
Barley-meal	20	20	20	25	30
Crocodile meat	15	10	8	4	3
Bran	25	25	25	25	25
Mineral supplement ..	3	3	3	3	3
Diet dates	as Group I	As Group I	6–8–48 to 20–8–48	21–8–48 to 9–9–48	10–9–48 to 23–10–48

TABLE I.—*(contd)*

Group III.—Pigs fed Crocodile meat and finished on Meat-meal as protein supplement.

Live Weight of Pigs	30–60 lb.	60–90 lb.	90–120 lb.	120–150 lb.	150–200 lb.
Maize-meal	37	42	44	44	40
Barley-meal	20	20	20	25	30
Crocodile meat	15	10	6	—	—
Meat-meal	—	—	—	3	2
Bran	25	25	25	25	25
Mineral supplement ..	3	3	3	3	3
Diet dates	As Group I	As Group I	As Group I	21–8–48 to 16–9–48	17–9–48 to 23–10–48

Mineral supplement fed to all pigs:—		
	Bone-meal	5 parts.
	Salt	3 parts.
	Lime	2 parts.

TABLE II

SUMMARY OF LIVE WEIGHT CHANGES

	GROUP I Fully fed Meat-meal		GROUP II Fully fed Crocodile meat		GROUP III Partly fed Crocodile meat	
Weighing dates	Pig Numbers		Pig Numbers		Pig Numbers	
	2630	2631	2632	2633	2634	2635
	lb.	lb.	lb.	lb.	lb.	lb.
10–6–48 ..	34	32	35	36	28	31
21–6–48 ..	52	50	45	51	51	52
28–6–48 ..	63	60	59	64	64	63
5–7–48 ..	65	69	64	68	68	68
12–7–48 ..	61	65	73	75	64	65
20–7–48 ..	70	77	78½	80	70	73
27–7–48 ..	72	80	82	82	75	77
5–8–48 ..	80	88	104	103	82	86
12–8–48 ..	86	93	115	115	87	92
19–8–48 ..	97	112	140	140	109	109
26–8–48 ..	121	128	142	143	126	119
2–9–48 ..	127	135	147	146	132	127
9–9–48 ..	136	142	155	154	140	135
16–9–48 ..	146	151	160	164	147	144
9–10–48 ..	186	193	203	197	192	170

BENZENE HEXACHLORIDE AS A CATTLE DIP

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(*Received for publication on 13th August, 1949*)

INTRODUCTION

This paper describes experiments carried out with Benzene Hexachloride (B.H.C.) to determine whether it is a satisfactory substitute for arsenic as a cattle dip.

In Kenya there are approximately 1,200 cattle dips of which about half are in cattle cleansing areas, in which dipping in arsenic (sodium arsenite) is compulsory. In the other dips, in the non-cleansing areas, arsenic is not compulsory, but at the time of starting these investigations practically nothing but arsenic was in use. It will thus be seen that a very large amount of this highly poisonous substance was scattered about the country.

The original purpose of these investigations was to decide whether arsenic can be replaced by any less poisonous substance. The main disadvantage of arsenic is its high toxicity to both man and animals. Unless considerable care is taken in its use and storage, serious losses from arsenic poisoning occur. Cattle seem to be attracted by the taste of arsenic and if it is left lying about or is spilt on the grass it is readily ingested. If cattle are not well watered before dipping they will drink the dip wash.

Another disadvantage is the scalding which is likely to occur if cattle are dipped during the heat of the day or are dipped in arsenic at frequent intervals, e.g. during an outbreak of east coast fever.

It is generally agreed that the milk yield falls on the day after dipping but it is not known whether this is related specifically to arsenic: it may be due merely to the general systemic effect of dipping cows-in-milk.

The only likely substitutes for arsenic appeared to be the gamma isomer of B.H.C. (known as gammexane or gamma B.H.C.) and D.D.T. A number of precise laboratory experiments were made to compare these agents with sodium arsenite. Known quantities of B.H.C. or D.D.T. were applied to the ears of rabbits and the ears were then exposed to ticks by enclosing them in bags containing known numbers of ticks.

In this paper B.H.C. is to be read to mean the gamma isomer of B.H.C. unless stated to the contrary.

The conclusions reached in this unpublished work were:—

(1) D.D.T. was found to be much less effective than B.H.C. against the brown tick, *R. appendiculatus*, and would be quite uneconomical to use in a cattle dip.

(2) B.H.C. was highly toxic to the brown tick, an application of 0.10 g. of gamma isomer sprayed on to each square metre of animal surface being sufficient to give a 100 per cent kill.

(3) Taking D.D.T. as unity, the relative toxicities of gamma B.H.C. and sodium arsenite, using a 50 per cent kill as a measure of toxicity, were 367 and 4.4.

(4) D.D.T. and sodium arsenite fell off more rapidly in toxicity on dilution than did B.H.C.

(5) Adult, nymphal and larval brown ticks did not differ significantly in their susceptibility to B.H.C.

(6) Both sexes were equally susceptible to B.H.C.

At the time that the above results were obtained there were no proprietary B.H.C. dips available in East Africa and it was therefore necessary to experiment with formulations prepared in this laboratory.

EXPERIMENTAL

Trials with Kabete Laboratory Formulations

As B.H.C. is almost completely insoluble in water it must be used in the form of either an emulsion or a suspension. After numerous trials, a miscible oil type of emulsion was produced, based on toluene, turkey red oil and soft soap. This gave a very stable emulsion on dilution with water; laboratory samples have remained fully emulsified after standing for ten months.

It was not possible to prepare enough to fill and maintain a cattle dip and so it was decided to test it, by spraying cattle with a hand-spray and in a sheep dip, using short-haired goats. The latter trial was carried out at Kabete using a locally designed sheep dip, and the former trial at the Department of Agriculture's African Agricultural School at Bukura, near Kakamega. Mr. Bradford, who was in charge of the school, ran the experiment on lines laid down by me until he went on leave, when Mr. Lavers took over and completed the trial. The African pupils participated in the work with much enthusiasm and interest.

Spraying Trial at Bukura.

The miscible oil concentrate used in this trial contained 1.5 per cent of gamma B.H.C., and was used at a dilution of 1 in 300 of water, giving 50 parts per million (p.p.m.) of gamma isomer.

Fresh wash was made up every week immediately prior to spraying, and an ordinary bucket-type hand-sprayer was used. Fifty cattle were taken and divided into five groups of ten each. One group was sprayed weekly, one fortnightly, one every three weeks and one every four weeks. The fifth group was unsprayed and acted as a control. The trial ran for five months during the wettest part of the year; it was hoped to run another trial during the dry season but unfortunately this could not be arranged.

The total number of ticks on the ten animals of a group were counted immediately prior to dipping; the ticks on the controls were counted weekly. At various intervals ticks were sent to Kabete for identification: Dr. Lewis kindly arranged for this to be done.

It is of interest to note that throughout the trial the ticks on the cattle were mainly the Bont tick, *Amblyomma variegatum;* comparatively few brown ticks, *Rhipicephalus appendiculatus,* were found. An occasional *Boophilus* was collected. During the last seven weeks of the trial ticks were counted separately on the ears and body, and it will be seen from Table I, which records all the results obtained, that the majority of ticks were on the body, particularly in the case of the sprayed cattle. This was to be expected as Bont ticks usually infest the body, and brown ticks the ears, and because Bont ticks are more difficult to kill than brown ticks.

The results given in Table I show that appreciable reductions occurred in the tick infestations on the one-, two- and three-weekly sprayed animals, but that the strength of the wash was not great enough to kill all the ticks. This has been borne out by later work which has shown that 83 p.p.m. of gamma B.H.C. are necessary to kill the Bont tick. In addition, the hand-sprayer used was obviously not as efficient as a dip, and the heavy rain must have washed off some of the B.H.C., especially when it occurred immediately after spraying.

Under the conditions of this trial, one-, two- and three-weekly sprayings were equally efficient, but none was fully satisfactory.

Dipping Experiments with Goats.

Two small paddocks were enclosed with wire netting and infested with brown ticks (*R. appendiculatus*), both adults and nymphæ, which had been bred in the laboratory by Dr. E. A. Lewis. Further additions of these ticks were made to the paddocks at various intervals.

The sheep dip was filled with 33 gallons of the diluted emulsion containing 50 parts per million of gamma B.H.C. Three short-haired goats were used for dipping and kept in paddock A, and three undipped, as controls, were kept in paddock B.

The results are too numerous to quote them all in detail, and will be given in detail for the first part of the trial and in summary only for the remainder of it. The three goats were dipped and allowed to dry and then put in the paddock; tick counts were made each day in the evening. Table II shows that up to three days after dipping no ticks had attached; on the fourth day three attached themselves, but these were dead by the fifth day. Up to the twelfth day no more had attached and further ticks were then put into the paddocks, resulting in eight attached and 11 dead ones being found the next day. Subsequently two of these eight died, but the remaining six started to feed. The three control animals during this period picked up over 30 ticks. These results show that the one dipping was effective for about 12 days. The weather during this time was wet.

Table III shows summarized results for the whole experiment. The goats were not dipped at regular intervals, but only when ticks once again began to become attached to them. These results show that a single dipping was effective for between 11 and 26 days according to whether it was wet or dry weather. In wet weather the B.H.C. would, to some extent, be washed off the animals and its residual effect would thus be shorter.

The same dip was used throughout and at the end of the experiment the volume of wash in the dip had been reduced to 17.8 gallons and analysis showed it to contain 48 parts per million of gamma B.H.C., i.e. a loss of only two parts per million or 4 per cent of the original.

Spraying Experiment.

Whilst this experiment was in progress another one to compare B.H.C. and D.D.T. was carried out with cattle. One animal was sprayed with an amount of B.H.C. emulsion calculated at the rate of 0.10 g. of gamma isomer per square metre of surface, with a small hand-spray to ensure that none was lost. Another animal was sprayed with D.D.T. emulsion at the rate of 7.5 g. per square metre, and a third was used as a control. These three were put in a tick-infested paddock and a daily tick count made for three weeks. The summarized results show that the B.H.C.-sprayed animal collected a total of 19 ticks in this period, but that 17 of them died, one dropped off and only one became engorged; the D.D.T.-sprayed animal collected 34 ticks, of which 20 died and 14 engorged; whilst in the same period the control collected 58 ticks, of which five died and 52 became engorged. These results show that the gamma B.H.C. was somewhat more effective than D.D.T. used at 75 times the strength.

The percentage kill of the ticks collected by the animals was: Control 8.6 per cent, D.D.T. 58.8 per cent, B.H.C. 89.5 per cent.

Commercial B.H.C. Dips

Before the above experiments had been completed there had been put on the market a commercial dip containing B.H.C. in the form of a paste, and known as Gamatox 2, which on dilution with water produced a fine suspension. As this settled fairly rapidly to the bottom of the dip tank it was essential to stir it up well before use, preferably by putting through a number of cattle, 10 to 20, and later redipping these particular animals.

As samples of this dip began to come in from farms for analysis it was noticed that many of them showed very low results, and after some months of use in Kenya a number of complaints came in from farmers that the dip was not killing ticks or that cases of tick-borne diseases were occurring. Some farmers complained that in spite of topping up as advised by the laboratory, as a result of analyses of samples sent by them, it seemed impossible for them to keep the dip up to strength.

A study of the available data showed that it was generally on those farms which dipped several hundred head of cattle at a time where trouble occurred; farmers dipping 100 or fewer cattle did not have trouble. From figures supplied by two farmers it appeared that the trouble might be due to removal by the hair of the cattle of more B.H.C. than was lost purely by mechanical removal; the hair might be filtering out some of the solid particles of the suspension as the excess wash drained off the animals. The figures submitted by these farmers suggested that this additional loss (now called "preferential removal") amounted to about 10 lb. of the Gamatox 2 paste for every thousand head of cattle put through the dip. It was, therefore, decided to test this out in a new dip tank which had just been built at Kabete especially for research work.

Trial with Gamatox No. 2 Paste Stock Dip.

Experience on farms had so far shown that this dip was very effective in controlling ticks provided its strength was maintained. As no paddocks were, at the time, available near the dip, it was decided to run the trial purely so as to ascertain what this preferential removal of B.H.C. by the cattle actually amounted to, and no data on tick control were kept. Accordingly, as many cattle as possible were dipped every three days, so as to bring the total number up quickly.

The tank was carefully calibrated and a scale painted up the side so that the level of the wash could be read after each dipping. Initially, 40 lb. of Gamatox 2 paste was made up to 3,235 gallons with water and after thorough stirring by means of a plunger followed by 20 cattle a sample was taken. This sample on analysis showed 53.3 parts per million of gamma isomer, equivalent to 33.8 lb. of Gamatox 2 paste instead of the 40 lb. put in. In my opinion this loss was due to the tank being new, the fresh concrete having some action on the B.H.C.; a black deposit was formed on the tank sides below the water level. This will be referred to again later.

For the purposes of this trial the initial strength of the wash was taken as that found by analysis, 53.3 parts per million of gamma isomer.

Results were too numerous to give in full, but are summarized into groups in Table IV, each group representing several weeks' dippings. In Table IV the Gamatox 2 content is calculated from the analysis figures of gamma content. Each group is treated separately, i.e. additions, losses, etc., refer to the particular group only and are not totals for the experiment.

From these figures the amount of Gamatox 2 lost mechanically, i.e. due to diminution in dip volume, can be calculated: thus in the first group above, after dipping 600 cattle, the volume of wash had gone down by 270 gallons and taking an average figure for gamma content the loss of 270 gallons of wash gave a Gamatox 2 loss of 2.5 lb. Since the total loss was 8.6 lb., the loss by preferential removal by the animals was 8.6 – 2.5 = 6.1 lb. Table V gives these losses for each group, together with the totals.

The preferential removal thus amounted to 66.3 lb. of Gamatox 2 for 6,929 cattle dipped, i.e. 9.6 lb. per thousand cattle. The preferential removal per thousand varied between 8.1 lb. and 11.7 lb. in the individual groups.

During the course of this trial further evidence was obtained that the cattle were actually removing Gamatox 2 in excess of that removed by ordinary mechanical means. The wash dripping off animals standing in the draining race was collected: also the wash running from this race into the small settling sump, and finally the wash returning from the settling sump to the main dip tank. These were analysed for gamma B.H.C. content and the results compared with that for the wash in the dip tank. Table VI shows the results of two such tests.

The figures in Table VI show that the wash running off the cattle back into the dip tank was only a little more than half the strength of the wash in the dip. This explains the steady loss in strength of the wash during the dipping. It will be noted that the presence of the small settling tank did not cause a significant reduction in gamma content. These figures were confirmed in a trial on a farm where the wash dripping off the animals contained 31 p.p.m. of gamma B.H.C. compared with 66.5 p.p.m. in the wash in the tank.

Comparison of Gamatox 2 and Tixol Dips.

This trial was undertaken for me on the European Settlement Board's farm at Turbo by kind permission of the Commissioner. It was carried out by Mr. Baer, the manager of the farm, and supervised by Mr. Preston, Veterinary Officer at Eldoret. Two dips were used, one containing Tixol at 1:400 and the other Gamatox 2 at 1:800. Owing to an unfortunate misunderstanding the trial only ran for three months, but in this time some useful results were obtained.

The cattle dipped in Gamatox 2 were divided into four groups: one group was dipped weekly and hand-dressed with sludge oil and tobacco extract, one group dipped fortnightly and hand-dressed, and the other two groups dipped weekly and fortnightly respectively without hand-dressing. Those dipped in Tixol were done weekly and all were hand-dressed.

Tick counts were made weekly and showed that after three months' dipping 30 cattle dipped in Tixol averaged nil to 30 ticks on them, whereas the Gamatox 2 dipped cattle showed, per 30 head:—

7-day dipping and hand-dressing, 7 ticks.

7-day dipping and no hand-dressing, 4 ticks.

14-day dipping and hand-dressing, 3 ticks.

14-day dipping and no hand-dressing, 9 ticks.

Thus Gamatox 2 compared very favourably with Tixol, especially when it is known that the part of the farm where the cattle for the Gamatox dip were kept was far more heavily tick-infested than the other, and also that those for the Tixol dip had been dipped in Tixol for some months past, whereas dipping in Gamatox 2 only started with the trial. The four different treatments with Gamatox 2 showed no significant differences amongst themselves.

The dip was kept up to volume by adding fresh Gamatox 2 as required at a strength of 1:800. Samples of the Gamatox 2 wash were taken for analysis at the start and after one, two and three months. Table VII shows the results, also giving the loss by preferential removal. These results show that the preferential removal of the Gamatox 2 was about 11 lb. per 1,000 head. Regular analysis of the Tixol showed a reduction of arsenic content by 8–9 per cent for every thousand cattle put through: this was made up as required.

Trials with Zondagam Liquid Stock Dip

Whilst the above trials were in progress with Gamatox 2, a new B.H.C. dip appeared on the market. It was called Zondagam and was of the emulsion type, and preliminary tests showed that the diluted emulsion held well and required little, if any, stirring before use. It has been tested out thoroughly, and careful records kept, in two dip tanks, one on a farm with the collaboration of the farmer, and one on the Veterinary Department's quarantine station at Kibigori.

Trial at Wolstaston Estate, Menengai.

Zondagam dip was first tested out on this farm. The trial had been in progress for some time before I first heard about it, and in consequence all the data that I would have planned for were not kept. Nevertheless, some very useful facts have emerged from it.

The dip was filled at 1 part of Zondagam to 250 parts of water and topping up was always done at this same strength. This is equal to 100 p.p.m. of gamma B.H.C. Monthly samples of the wash were sent to Kabete for analysis.

After seven months' use the strength had fallen to 1 in 460 and eight gallons extra Zondagam were then added, which brought the strength up to 1 in 260. During this period approximately 18,000 cattle had gone through the dip; this gives a loss by preferential removal of 0.45 gallons per thousand head. At the end of a further seven months eight gallons of Zondagam were required to bring the strength back to about 1 in 250; as approximately 18,000 cattle had again been through the dip the preferential removal was again 0.45 gallons per thousand. It thus averaged this amount (0.45) for the whole 14 months.

Tick counts were not made, but a careful watch was kept on the number of ticks found on the cattle. Hand-dressing was carried out under the tail only by applying the wash from the dip with a cloth.

When I first saw the cattle, about three months after the start of the trial, there were very few ticks on them. On the body and in the ears there were practically none, but under the tails ticks could be found in moderate numbers; they were mostly Bont ticks (*A. variegatum*), with a few brown ones (*R. appendiculatus*). Throughout the whole 18 months of the trial the number of ticks on the cattle has remained as above. This shows very good control by Zondagam, except where used under the tail for hand-dressing; a higher concentration, say 1 in 100, would probably have been fully effective here.

Due to shortage of water because of very dry weather during January and February, 1948, the cattle were not dipped regularly and in March an outbreak of east coast fever occurred. This outbreak was stopped entirely in three weeks by dipping the cattle every other day during this period.

The farmer reports that no harmful effects on the animals occurred except during the period of alternate day dipping when there was a small amount of temporary cracking and external soreness of the teats: this entirely cleared up when normal dipping intervals were resumed.

Trial at Kibigori.

A newly-built dip tank at Kibigori was placed at my disposal by the Veterinary Department, and 100 cattle for use in the trial were loaned by the Meat Marketing Board. The running of this carefully controlled experiment at a station over 200 miles away has only been possible through the interest and keen supervision of Mr. G. Mamais of the Meat Marketing Board, who is in charge of the Kibigori Station.

In this trial careful tick counts were made weekly, and monthly collections of ticks were sent to Kabete, where Dr. Lewis kindly identified them. Kibigori is an extremely "dirty" area for ticks, the ten control animals at the beginning of the experiment having over 6,000 ticks on them.

The 100 cattle were divided into two herds, A and B, of 45 animals each, which were dipped once a week, and a third group of ten to act as controls. Ten animals each in herds A and B were marked and the tick counts were always made on these same animals. The two herds and the controls were all kept in separate *bomas* at night, but had to be grazed and watered together by day. Herds A and B were dipped regularly at seven-day intervals.

The Zondagam dip wash was initially made up to one gallon in 500 gallons of water, equivalent to 50 p.p.m. gamma isomer. After eight weeks it was topped up to 1 in 400, equivalent to 62.5 p.p.m., and after a further eight weeks to 1 in 300, or 83 p.p.m. gamma isomer.

A sample of the wash for analysis was taken every week immediately at the end of dipping. An initial loss of B.H.C. occurred in this new dip at its first filling as in the new Kabete dip with Gamatox 2: it amounted to 0.3 gallons of Zondagam concentrate. Tick counts were made three times weekly on each of the ten marked animals in herds A and B: they were made one, four and six days after dipping. Tick counts on the controls were made twice weekly.

During the first eight weeks total ticks only per ten animals were counted, but thereafter they were counted separately on the body, ears and tail. At first herds A and B were treated alike, but after the first eight weeks herd B was also hand-dressed with the wash.

Very interesting results were obtained as regards the toxic effect of Zondagam on ticks. The data are very numerous and have had to be condensed very considerably. Table VIII gives a summary of the tick counts; the first three are for one, four and six days after the first dipping, the remainder are for one day after dipping in each case. Table IX gives a summary showing the proportion of the different species of ticks collected from the cattle. In the control only one animal was used and the number of ticks collected from it multiplied by ten to give the figures shown in this table; it was not possible to use more than one animal without upsetting the weekly tick counts; in herds A and B ten animals each were used, not being any of those used in the weekly counts.

The only species found were the brown tick (*R. appendiculatus*), the Bont tick (*A. variegatum*) and two *Boophilus ticks.*

The results, summarized in Tables VIII and IX, show an immediate big reduction in both brown and Bont ticks by dipping in Zondagam at 1 in 500 (50 p.p.m. gamma B.H.C.), from several thousand to a few hundred per ten animals; continued weekly dipping at this strength did not, however, reduce the tick count below about 165 per ten animals, mostly in the ears.

On topping-up to 1 in 400 (62.5 p.p.m. gamma B.H.C.), weekly dipping for eight weeks brought the number down in herd A to 55 on ten animals and in herd B, which was hand-dressed in the ears and on the tail, to 38. At this stage nearly all the brown ticks present were in the ears.

On topping-up to 1 in 300 (83 p.p.m. gamma B.H.C.), the total ticks were still further reduced to about 33 per ten animals; and of great interest is the fact that since the first dipping at this strength not a single Bont tick has been found over a period of seven months, and brown ticks have been found in the ears only.

Hand-dressing with the wash from the dip has had little or no effect on the ticks in the ears; grease is now being tried.

It will be recalled that with Gamatox 2 an appreciable loss occurred through preferential removal of the suspended particles in the wash by the cattle. Zondagam is an emulsion and not a suspension and therefore one would not expect this same loss to take place; some reports, however, state that loss occurs with emulsions through absorption by the hides of the cattle of the oily constituents of the emulsion. Careful check was kept of the amounts of Zondagam and water added, and of the number of cattle dipped, and regular chemical analyses of the dip wash were made. Table X summarizes the results.

From the figures for loss of volume of the dip wash the amount of Zondagam lost by this mechanical removal was calculated; this amount deducted from the total loss, given in the right-hand column of Table X, shows the loss by preferential removal. Table XI gives the actual figures.

The preferential removal thus amounted to 1.8 gallons for 5,166 cattle dipped, i.e. 0.35 gallons per thousand head; it varied between 0.25 and 0.45 gallons per thousand in the different groups, and tended to be slightly higher the greater the concentration of Zondagam in the dip.

The wash dripping off the animals in the draining race was collected on three occasions and gave the results shown in Table XII.

The figures in this table show that very little gamma isomer was lost by preferential removal by the cattle; again the loss tended to increase with increasing concentration of Zondagam.

Preferential Removal Trial in Sheep Dip.

This trial was made with short-haired goats in a sheep dip, using four different dip wash preparations. Although the conditions were not identical with those in normal cattle dipping, they were nevertheless nearly so, and they were identical amongst themselves for the four preparations tested.

The dip tank was filled with the required wash and six goats were dipped daily for six weeks. No topping-up was done. At the end of the six weeks the volume of the wash was reduced to about a third of the original volume. Samples for analysis were taken weekly. Table XIII shows the results.

The figures shown in this table, besides confirming that the preferential removal is appreciably greater with the paste dip than with the emulsion type, also show that it is much lower with the miscible oil type, and much greater with the dispersible powder type, than with either of the other two.

Feeding B.H.C. to Animals.

As a result of various reports that insects feeding on animals which had eaten B.H.C. were killed by obtaining a toxic dose of the insecticide from the blood, a number of trials were carried out to test this.

Rabbits.—Two rabbits, each weighing approximately 1.6 kilos, were each given 40 mg. of pure gammexane on five successive days, i.e. a total of 200 mg. per animal. The gammexane was fed dry mixed with bran. On the sixth day five male and five female *R. appendiculatus* (brown ticks) were put on each ear, enclosed in an ear-bag. One untreated rabbit was used as a control. The ears were examined daily. Table XIV shows the results.

Thus all the female ticks were dead within three days and all the males within four days. The rabbits showed no ill-effects from the dosing.

Sheep.—Eight sheep were weighed to the nearest kilo and dosed with pure gammexane as follows:—

1.—Weight 29 kilos, given 0.145 g.=5 mg. per kilo.

2.—Weight 29 kilos, given 0.29 g.=10 mg. per kilo.

3.—Weight 27 kilos, given 0.405 g.=15 mg. per kilo.

4.—Weight 27 kilos, given 0.135 g.=5 mg. per kilo, repeated next day.

5.—Weight 31 kilos, given 0.31 g.=10 mg. per kilo, repeated next day.

6.—Weight 33 kilos, given 0.495 g.=15 mg. per kilo, repeated next day.

7.—Weight 17 kilos, control.

8.—Weight 38 kilos, control.

Nos. 4, 5 and 6 thus received two doses at 24 hours' interval. The gammexane was put into capsules which the sheep swallowed. With Nos. 1, 2 and 3 five male and five female ticks, *R. appendiculatus*, were put on the left ear immediately after dosing and five of each on the right ear 24 hours later. With Nos. 4, 5 and 6 five of each sex were put on each ear immediately after the second dose of gammexane. The controls received a similar number of ticks on the left ear on the first day, and on the right ear 24 hours later. Bags were placed over all ears to prevent loss of ticks. The results are shown in Table XV.

No difference in rate or number of deaths of males and females was noted. The figures in the above table show that the doses given were not enough to give a complete kill of the ticks, although high mortalities were produced. The heavier doses showed a quicker initial kill than the lighter ones.

A further test was made in which two sheep were dosed twice at the rate of 20 mg. per kilo of weight on two successive days. Ticks placed on the ears immediately after the second dose were all dead in three and four days respectively; a control sheep showed no deaths in four days.

Further trials showed that a single dose of 30 mg. per kilo gave 90 per cent mortality after ten days, and single dose of 40 mg. per kilo gave 100 per cent mortality in five days. This last dose had a slight toxic effect on the two sheep used, rendering them unsteady on their feet for about three hours; none of the other doses caused any noticeable ill-effects.

From these trials it appears that a given dose of gammexane was more effective in killing ticks when fed to sheep in two equal doses 24 hours apart than when fed in one single dose. The minimum amount required to give 100 per cent mortality was approximately two doses of 20 mg. per kilo bodyweight.

Cattle.—Six oxen were fed on pure gammexane at the rate of 30 mg. per kilo of bodyweight per dose. Nos. 1 and 2 received one dose, Nos. 3 and 4 two doses on successive days, and Nos. 5 and 6 three doses on successive days.

Immediately after the last dose in each case five ticks, adult *R. appendiculatus*, were placed on each ear; 24 hours later they were all removed and the number which were dead or subsequently died within four days noted, and five more ticks placed on each ear. This removal and replacement was repeated daily as long as 100 per cent mortality was obtained.

The summarized results are shown in Table XVI.

Animals 5 and 6 suffered some toxic effects after receiving the third dose and were unsteady in their gait; these effects wore off in a few hours.

Comparing the results in Table XVI with those for sheep, it will be seen that the same doses per kg. bodyweight were much more effective with the cattle than with the sheep; this may be due to the fact that *R. appendiculatus* appears to feed much more readily on the former.

It thus appears that the blood of animals can be rendered appreciably toxic to the brown tick for up to three weeks. This method is not, however, likely to be of any economic value because before being killed the tick has an appreciable feed on the animal, and if it is an infected tick it will pass on the infection to the animal before it dies.

Gamatox Liquid Stock Dip.

Although this dip is on sale in the Union of South Africa, it is not, at the time of writing (June, 1949), on sale in East Africa; it has, however, been made available for testing by the kindness of the manufacturers. This preparation is an emulsion type dip and the makers issue a warning that preferential removal will be high. This trial was made to determine the actual loss by preferential removal and no attempt was made to assess its toxicity to ticks.

The Kabete experimental dip was filled with ten gallons of the stock in 3,315 gallons of water, giving 75 parts per million of gamma isomer, and cattle were dipped every three days. Additions of water and stock were made as required, based on analysis results. Table XVII gives a summary of the results obtained, the last column showing the average gamma content during each part of the trial; all other figures are totals to date. These figures show that preferential removal is high, amounting to an average of 3.3 gallons per 1,000 cattle for a total of 6,803 animals dipped. This is about three and a half times as high as for Gamatox 2.

The results are slightly more variable than with either Gamatox 2 or Zondagam, and the preferential removal does not seem to bear any relation to the gamma content of the wash, as was the case with the first two. Samples were taken of the wash dripping off the cattle in the draining race, of the wash running from the race to the small settling tank and of the wash returning to the dip, and Table XVIII shows the results. These figures show an appreciable removal of B.H.C. by the cattle.

It is unlikely that this dip would be economic to use under East African conditions.

Experimental Dipping with Gamatox 2.

Early in the work on B.H.C. dips an experiment was carried out in conjunction with Mr. Melville, of the Kenya Agricultural Department, using Gamatox 2 dip, on Kiltannon Farm with the co-operation of the owner. The wash was at first made up to a dilution of 1 in 1,000. After five weeks it was increased to 1 in 800, and after a further nine weeks to 1 in 600.

The cattle were dipped weekly and a tick count was made on ten of them immediately prior to dipping, and again 24 hours later. The ticks on ten undipped animals, to act as controls, were similarly counted. A large proportion of the ticks found on the cattle were Bont ticks, *A. variegatum.*

A detailed report on this work will be published later and only a summary of the results is given now. Table XIX shows the results obtained in brief. It will be seen that ticks were not completely controlled at any of the strengths, although they were appreciably reduced. At this time loss by preferential removal had not been worked out and the wash was merely topped-up when necessary. Theo column showing the strength of the wash in parts of gamma insomer per million indicates a steady drop in all the groups.

It has since been shown that a content of 83 parts per million is necessary to control the Bont tick, and it will be seen from the table that this strength was in fact never actually reached. Under these circumstances complete control of ticks should not have been expected.

The use of Gamatox 2 was continued by the farmer and when, about a year later, we commenced another trial with a different B.H.C. dip we had to abandon the test because the cattle were not picking up sufficient ticks to make the trial worth while. The Gamatox 2 had, therefore, been effective over a period of about a year.

During this trial two interesting results were obtained. There was an appreciable sized settling tank between the draining race and the dip, a fairly common practice with arsenic dips, and a sample of the mud at the bottom of it was taken after Gamatox 2 had been in use for four and a half months: this mud was found to contain 1,550 parts per million of gamma isomer, i.e. about 20 times as much as was in the wash. This proves that B.H.C. was settling all the time to the bottom of this sump and being lost from the dip, and shows that only a very small settling tank or even just a piece of fine gauze in the return channel between the race and the dip tank should be used. When the dip was emptied, after being in use for 11 months, a sample of the mud taken from the bottom had a gamma content of 1,482 p.p.m.; this shows that an appreciable amount of the B.H.C. had also settled into the mud at the bottom of the tank.

DISCUSSION

The results obtained during these investigations show conclusively that there are now on the market formulations of B.H.C. which are as effective as arsenic in controlling ticks on cattle. If used and maintained at the correct strength, B.H.C. will kill all the usual species of ticks which infest cattle in East Africa. It has been shown that a concentration of 83 parts per million of the gamma isomer is sufficient to kill all ticks, including the Bont, *A. variegatum*, which is normally the most difficult one in Kenya to control. On a few farms where the Bont-legged tick, *Hyalomma* sp. occurs it would probably be necessary to use the wash at 100 parts per million; this tick is extremely difficult to control with arsenic, but reports received from several reliable farmers indicate that gamma B.H.C. at 100 p.p.m. will control it.

Provided that the available strength of the gamma B.H.C. is maintained the exact formulation of the dipping fluid may vary considerably, from a pure emulsion to a suspension, and still give satisfactory tick control. In actual dipping practice, however, the formulation can make an appreciable difference in the ease of use and in the cost. It has been shown that, in addition to normal removal of the dip wash by the cattle by mechanical means, there is an actual loss of B.H.C. brought about by the fact that the wash draining off the animals after they emerge from the dip contains less B.H.C. than does the wash in the tank. This loss is probably caused by absorption of the B.H.C. on the hides and/or filtration of the suspended particles by the hairs; it has been called "preferential removal". It is obvious that the greater this preferential removal the more expensive will be the dip in use, and also the more chance there will be of the wash falling below strength and thus allowing ticks and tick-borne diseases to spread.

Trials with a laboratory preparation of a miscible oil emulsion showed it to be very simple to use as it required no stirring and the loss by preferential removal was extremely low; it would, however, probably be too expensive for practical purposes.

Zondagam, which is an emulsified preparation, has proved to be the easiest and cheapest to use of the proprietary preparations at present on the market. It requires very little, if any, stirring; after standing for a week the concentration of B.H.C. in the top layers of the wash has not fallen to half that of the total contents, and one or two cattle passed through stir it up adequately. The loss by preferential removal is low and no risk occurs of the wash becoming too weak during dipping unless very large numbers of cattle are dipped at a time. Unless Bont-legged ticks are present in any quantity, this dip gives effective tick control if used at a dilution of one gallon to 300 gallons of water for filling the tank and for normal topping-up, together with the addition of an extra half gallon of dip for every 1,000 cattle passed through. If over 1,000 cattle are dipped at a time this addition should be made either at the commencement or during the course of dipping. If many Bont-legged ticks are present, Zondagam should be used at a dilution of 1 in 250 instead of 1 in 300.

Gamatox 2, which is a paste suspension type of dip, requires more care in its use. The suspended particles settle fairly rapidly and the wash requires a considerable amount of stirring before it is used. It has been found that at least 20 cattle must be put through to give adequate stirring and these animals must be redipped as they will have passed through too weak a wash for safe tick control. The preferential removal with this dip is fairly high and nearly all the causes of complaint against it have been due to the farmer not realizing that fairly large additions of dip must be made in order to keep its strength up. This dip gives effective tick control if used at a dilution of 10 lb. to 600 gallons of water for filling and for normal topping up, together with the addition of an extra 10 lb. of dip for every 1,000 cattle put through. It will be seen from this that if a farmer starts dipping with his wash at just correct srength and puts through 1,000 cattle, then the last animals will go through too weak a solution: thus with a dip of 3,000 gallons capacity, if the wash starts at 1 in 600 it will have fallen to about 1 in 750 when 1,000 cattle have been through. It is, therefore, necessary to make these additions in advance or during dipping if more than, say, 500 cattle are dipped at a time. If many Bont-legged ticks are present Gamatox 2 should be used at a dilution of 1 in 500, i.e. 10 lb. to 500 gallons of water.

Gamatox liquid stock dip, which is not at present on the East African market, has such a high loss by preferential removal that it would not be economic to use. It would be very troublesome to keep up to strength because of the many necessary additions which would have to be made, and the farmer would thus run the risk of the wash frequently being too weak to control ticks effectively. The maker's instructions are to use it mixed with arsenic and it is especially recommended for use where the arsenic-resistant blue tick occurs; as this tick is not known in East Africa, this dip is unlikely to find much use here.

A dispersible powder dip prepared from I.C.I. "Dispersible Powder P.736" showed, as was expected, a very high loss by preferential removal and a very high rate of settling in the tank. The dispersible powder type of formulation is, for these reasons, unsuited for use as a dip.

All the above four dips give satisfactory tick control when correctly used, but the dispersible powder type is extremely difficult to use correctly, and the paste suspension type is definitely more difficult than the emulsion types.

During one of these trials with Gamatox 2 it was found that the mud at the bottom of the tank, when the dip was emptied after 11 months' use, contained 1,482 p.p.m. of gamma isomer. A sample of mud taken from a dip which was emptied after seven and a half months' use with Zondagam contained 135.5 p.p.m. gamma isomer. Both dips had been running at approximately 83 p.p.m. This shows, as was to be expected, that with suspension type dips part of the B.H.C. is lost by settling into the mud at the bottom, whereas with emulsion dips this loss is comparatively small. By cleaning out and refilling the dip more frequently the loss would probably be somewhat reduced.

In the Zondagam dip mentioned above the farmer was in the habit of skimming off quantities of hairs that collected on the top of the wash: analysis of these showed them, when dried, to contain 1,124 p.p.m. of gamma isomer. It would thus appear that removal of the hairs caused an appreciable loss of B.H.C. and this practice is therefore inadvisable.

As regards the life of B.H.C. dips, both Zondagam and Gamatox 2 have been found to be fully effective after 12 months' continuous use, and no cases of rapid deterioration have been reported. Recent data obtained from a few farms where large numbers of cattle are kept suggest that it is advisable to clean out the dip after about 30,000 animals have been through. It is suggested that tanks containing B.H.C. dips should be cleared out and refilled after 30,000 cattle have been through or every 12 months, whichever is the sooner. There is no trouble about disposal of the old wash as it is non-poisonous; it has been found very useful for killing flies in cattle stalls, on manure heaps, etc.

It had been hoped that a residual or lasting effect with B.H.C. would have been found, which would have permitted dipping at longer intervals than seven days. Unfortunately very little evidence to this effect has been obtained. With the laboratory miscible oil emulsion dip goats were protected for up to three weeks in dry weather and for nearly two weeks in wet weather by one dipping, but general experience with cattle is that it is not safe to extend the dipping interval beyond seven days: outbreaks of tick-borne diseases have occurred on farms where this has been done, with both Zondagam and Gamatox 2. If such outbreaks do occur, it is advisable, and quite safe, to dip at four- or even three-day intervals until the disease has been controlled.

Cattle may safely be dipped in B.H.C. washes at any time of the day and working oxen may be used immediately after dipping without risk. No burning or other harmful effects are caused by using the wash too strong, even if several times over strength, and cattle may be safely dipped at very short intervals, as shown by one owner who dipped his cattle in Zondagam every other day for three weeks during an outbreak of east coast fever without any ill-effects.

B.H.C. dip washes appear to have a definite beneficial effect on the skin of cattle during mange and cuts and sores and also on ophthalmia and similar eye troubles: this has been particularly noticed when using Zondagam. At Kibigori before dipping was practised, one herdsman was employed solely in dressing the cattle for such cuts, sores, etc. Shortly after starting to dip in Zondagam they had all healed up, and as the animals have since all remained in a healthy condition the herdsman in question is no longer needed.

Most farmers say that there is a reduction in milk yield on the day that their milking cows are dipped in arsenic. The claim is made that dipping in B.H.C. preparations does not cause a similar drop in yield. This matter has been discussed with many farmers both in East Africa and South Africa and the general opinion is that arsenic does cause such a drop whilst B.H.C. does not. However, some farmers say that they get no, or very little, drop with arsenic.

When B.H.C. dip washes are put into a new and previously unused cement dipping tank a certain loss of B.H.C. occurs, probably due to action of the lime in the cement. Under these circumstances a sample should be taken for analysis at the first dipping so that the amount lost can be replaced, otherwise the dip wash will be too weak from the start. This loss only occurs once.

If B.H.C. is fed to cattle in the correct quantity, sufficient of it enters the blood stream within 24 hours to render the blood toxic to ticks which feed on it. By giving two or three successive daily doses the blood will remain toxic for up to 23 days. Two successive doses produced no ill-effects on the cattle, but three successive doses caused slight unsteadiness lasting for a few hours. This property of B.H.C. does not appear to have any economic importance because if an infected tick feeds on the animal it will pass on the infection before receiving sufficient B.H.C. to be killed. It is of interest in showing that B.H.C. acts as a stomach poison as well as killing by the more usual method of contact.

It has been found that if sheep are put through a cattle dip the loss by preferential removal is very high and this practice is therefore not recommended. If it is necessary at any time to dip sheep, the wash should be sampled and analysed at once so that it can be brought back to strength.

SUMMARY

B.H.C. dips have been produced which, if correctly used, are at least as effective as arsenic dips in controlling ticks on cattle. They are quite safe to use even at several times the recommended strength, and dipping may be done at any time of the day without risk.

All B.H.C. dips at present on sale in East Africa show a loss of active ingredients, proportional in amount to the number of cattle dipped, by preferential removal. This loss must be made up by adding extra dip over and above the amount used for normal topping-up.

The proprietary dips Zondagam and Gamatox 2 are, when correctly used, entirely satisfactory in controlling ticks. The recommended strengths for general use are:—

Zondagam.—One gallon to 300 gallons of water for filling and normal topping-up, together with half a gallon extra for every 1,000 cattle dipped.

Gamatox 2.—10 lb. to 600 gallons of water for filling and normal topping-up, together with 10 lb. extra for every 1,000 cattle dipped.

No other B.H.C. dip can at present be recommended.

It is recommended not to skim off hairs floating on the top of B.H.C. dips as this will remove some of the B.H.C.

No residual or lasting effect of B.H.C. on cattle has been found which would make it safe to extend the dipping interval beyond seven days.

It is recommended to clean out and refill B.H.C. dips after 30,000 cattle have been through, or every 12 months, whichever is the sooner. It is not advisable to put sheep through these dips owing to the very high rate of preferential removal.

B.H.C. dips have a beneficial effect on cuts, sores, etc., and also on ophthalmia and similar eye troubles.

If cattle are fed on B.H.C. their blood becomes toxic to ticks, but if the ticks are infected they will pass on the infection to the cattle before they themselves die.

NOTE.—The above work was carried out on ordinary short-haired Kenya cattle; recent results obtained with longer-haired cattle indicate that the "preferential removal" may be up to twice as much as stated above, i.e. up to 20 lb. with Gamatox 2 and up to one gallon with Zondagam per 1,000 head of cattle. Further work is in progress on this point.

TABLE I

Tick Counts for Five Groups of Cattle, Together with Rainfall Records

Weeks	1 Weekly			2 Weekly			3 Weekly			4 Weekly			Control			Rainfall in inches
	Ears	Body	Total	Ears	Body	Total	Ears	Body	Total	Ears	Body	Total	Ears	Body	Total	
1	—	—	168	—	—	110	—	—	143	—	—	197	—	—	243	—
2	—	—	176	—	—	—	—	—	—	—	—	—	—	—	256	—
3	—	—	176	—	—	83	—	—	—	—	—	—	—	—	289	—
4	—	—	144	—	—	—	—	—	119	—	—	—	—	—	257	—
5	—	—	165	—	—	94	—	—	—	—	—	145	—	—	228	2·20
6	—	—	124	—	—	—	—	—	—	—	—	—	—	—	285	2·69
7	—	—	51	—	—	57	—	—	74	—	—	—	—	—	154	1·79
8	—	—	52	—	—	—	—	—	—	—	—	—	—	—	140	5·48
9	—	—	61	—	—	45	—	—	—	—	—	67	—	—	93	2·63
10	—	—	68	—	—	—	—	—	25	—	—	—	—	—	147	4·59
11	—	—	41	—	—	34	—	—	—	—	—	—	—	—	160	2·69
12	—	—	46	—	—	—	—	—	—	—	—	—	—	—	108	1·76
13	—	—	10	—	—	17	—	—	25	—	—	41	—	—	32	1·65
14	—	—	11	—	—	—	—	—	—	—	—	—	—	—	30	0·21
15	—	—	46	—	—	27	—	—	—	—	—	—	—	—	53	0·32
16	18	22	40	—	—	—	3	7	10	—	—	—	33	40	73	1·63
17	7	18	25	4	12	16	—	—	—	3	36	39	18	49	67	2·38
18	8	22	30	—	—	—	—	—	—	—	—	—	11	41	52	0·32
19	7	27	34	4	9	13	1	6	7	—	—	—	37	58	95	1·43
20	2	7	9	—	—	—	—	—	—	—	—	—	27	35	62	0·86
21	9	9	18	5	12	17	—	—	—	15	31	46	26	57	83	6·34
22	7	18	25	—	—	—	1	6	7	—	—	—	43	55	98	2·17
Per cent reduction of ticks beginning/end of experiment			85	—	—	84·5	—	—	95	—	—	77	—	—	60	

TABLE II

DIPPING EXPERIMENT WITH GOATS

Treatment	No. of days after dipping	Ticks on dipped goats		Ticks on controls	
		attached	dead	attached	engorged
Paddocks reinfested	1–3	nil	nil	30	
	4	3	nil	39	
	5	nil	3	38	1
	6–12	nil	nil	29	9
	13	8	11	33	
	15	6	2	31	2
	17	6	0	31	
Goats redipped	1	nil	6	31	

TABLE III

DIPPING EXPERIMENT WITH GOATS

Treatment	No. of days after dipping	Live ticks attached on		Weather
		Dipped goats	Control goats	
Goats dipped	Up to 12	nil	38	Very wet.
Paddocks reinfested	13 to 17	6	31	
Goats redipped	1 to 14	nil	31	Fairly wet.
Paddocks reinfested	15 to 18	nil	19	
	19 to 23	9	19	
Goats redipped	1 to 19	nil	18	Fairly dry.
	20 to 23	3	18	
Goats redipped	1 to 16	nil	29	Fairly dry.
Paddocks reinfested	17 to 21	nil	31	
	22 to 25	7	30	
Goats redipped	1 to 18	nil	32	Dry.
Paddocks reinfested	19 to 22	nil	30	
	23 to 26	8	31	
Goats redipped	1 to 21	nil	26	
Paddocks reinfested	22 to 24	nil	25	
	25 to 30	9	24	
Goats redipped	1 to 15	nil	21	
Paddocks reinfested	16 to 20	nil	21	
	21 to 24	7	20	
Goats redipped	1 to 15	nil	22	Fairly dry.
Paddocks reinfested	16 to 18	nil	21	
	19 to 23	11	20	
Goats redipped	1 to 11	nil	27	Wet.
	12 to 16	7	29	
Goats redipped	1 to 10	nil	29	
Paddocks reinfested	11 to 13	nil	31	
	14 to 17	9	33	
Goats redipped	1 to 10	nil	32	Very wet.
Paddocks reinfested	11 to 12	nil	34	
	13 to 16	8	33	
Goats redipped	1 to 10	nil	28	Wet.
Paddocks reinfested	11 to 14	nil	30	
	15 to 18	9	30	Fairly dry.
Goats redipped	1 to 10	nil	27	Dry.
Paddocks reinfested	11 to 19	nil	29	
	20 to 22	7	28	
Goats redipped	1 to 15	nil	26	Very dry.
Paddocks reinfested	16 to 26	nil	21	
	27 to 30	6	21	

TABLE IV.—TRIAL WITH GAMATOX No. 2 PASTE

Ref. No.	Additions to dip		Cattle dipped	Volume lost	Gamma content	Gamatox 2	
	Water	Gamatox 2				content	lost
	Gallons	lb.		Gallons	p.p.m.	lb.	lb.
A	3,235	40	—	—	53·3	33·8	—
B	—	—	339	200	46·5	28·2	5·6
C	—	—	600	270	42·5	25·2	8·6
D	450	10	278	55	53·0	34·7	—
E	—	—	508	225	44·5	27·6	7·1
F	—	—	949	315	40·0	24·1	10·6
G	470	20	125	45	67·3	44·1	—
H	—	—	641	90	62·0	40·6	3·5
I	—	—	973	157	57·0	36·5	7·6
J	—	—	1,514	360	42·5	25·6	18·5
K	315	10	122	10	54·0	35·8	—
L	—	—	721	202	41·1	25·7	10·1
M	—	10	78	45	58·5	35·7	—
N	—	—	441	360	50·9	30·2	5·5
O	360	10	102	22	60·8	40·2	—
P	—	—	925	292	51·3	31·1	9·1
Q	—	—	1,233	415	40·4	23·5	16·7
R	415	15	214	45	58·5	38·4	—
S	480	—	1,471	715	28·3	17·5	20·9
TOTAL	5,725	115	6,929	2,637	—	—	90·9

TABLE V.—TRIAL WITH GAMATOX No. 2 PASTE

GROUP	A to C	D to F	G to J	K to L	M to N	O to Q	R to S	Total
	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
Total loss	8·6	10·6	18·5	10·1	5·5	16·7	20·9	90·9
Mechanical loss . .	2·5	2·9	4·3	2·9	1·6	4·2	6·2	24·6
Preferential removal . .	6·1	7·7	14·2	7·2	3·9	12·5	14·7	66·3
P.R. per 1,000 . .	10·1	8·1	10·2	10·6	8·8	10·1	11·7	9·6

TABLE VI.—TRIAL WITH GAMATOX No. 2 PASTE

	Gamma B.H.C. in p.p.m.	
	I	II
Wash in dip tank . .	46·5	58·5
Dripping off cattle . .	24·5	34·0
From race to sump . .	26·5	38·5
From sump to tank . .	24·5	34·0

TABLE VII.—LOSS OF GAMATOX 2 IN DIP

Sample	Gamma content	Gamatox 2		Cattle dipped	Loss per 1,000 head
		content	loss		
	p.p.m.	lb.	lb.		lb.
Start	62·0	40	—	—	—
1 month	62·5	40	—	442	—
2 months	43·5	30	10	885	11·5
3 months	35·5	15	25	2,285	11·0

TABLE VIII

LIVING TICKS COUNTED ON TEN CATTLE THE DAY AFTER DIPPING

A.—Zondagam at 1 in 500 (50 p.p.m. gamma isomer). No hand-dressing

DATE		CONTROL				HERD A				HERD B				NOTES
		Body	Ears	Tail	Total	Body	Ears	Tail	Total	Body	Ears	Tail	Total	
April	24	—	—	—	5,627	—	—	—	3,003	—	—	—	1,338	Dipped 23rd
	27	—	—	—	5,588	—	—	—	239	—	—	—	461	
	29	—	—	—	5,615	—	—	—	181	—	—	—	154	
May	1	—	—	—	4,062	—	—	—	199	—	—	—	156	Dipped 30th
	8	—	—	—	3,781	—	—	—	267	—	—	—	152	
	15	—	—	—	3,247	—	—	—	206	—	—	—	200	
	22	—	—	—	3,671	—	—	—	271	—	—	—	220	
	29	—	—	—	2,348	—	—	—	235	—	—	—	209	
June	5	—	—	—	2,401	—	—	—	180	—	—	—	188	
	12	—	—	—	2,206	—	—	—	154	—	—	—	179	
B.—Topped up to 1 in 400 (62·5 p.p.m.). Herd B hand-dressed with the dipwash														
June	19	551	1,148	91	1,790	12	144	2	158	19	192	3	214	Dipped 18th
	26	432	963	76	1,471	5	90	3	98	9	95	3	107	
July	3	433	970	86	1,489	1	77	—	78	10	71	6	87	
	10	459	956	63	1,478	9	85	6	100	15	101	6	122	
	17	366	803	26	1,195	1	62	1	64	4	66	—	70	
	24	353	804	40	1,197	4	64	1	69	6	50	3	59	
	31	349	696	36	1,081	—	62	—	62	—	47	—	47	
August	7	335	690	36	1,061	1	54	—	55	—	38	—	38	
C.—Topped up to 1 in 300 (83 p.p.m.). Herd B hand-dressed with the dipwash														
August	14	325	671	48	1,044	—	44	—	44	—	43	—	43	
	28	330	688	34	1,052	—	38	—	38	—	40	—	40	
September	11	338	700	34	1,072	—	47	—	47	—	42	—	42	
	25	348	704	38	1,090	—	59	—	59	—	59	—	59	
October	23	322	644	40	1,006	—	49	—	49	—	39	—	39	
November	20	321	647	40	1,008	—	43	—	43	—	42	—	42	
December	18	319	614	40	973	—	38	—	38	—	41	—	41	
January	15	326	614	39	979	—	41	—	41	—	42	—	42	

TABLE IX

NUMBERS OF DIFFERENT SPECIES OF LIVING TICKS ON TEN CATTLE

Herd	Species	1 in 500		1 in 400	Aug.	1 in 300		Jan.
		May	June	July		Sept.	Nov.	
Control	Brown ..	770	2,720	1,230*	980	970	1,010	970
	Bont ..	600	590	500	350	330	330	290
	Total ..	1,370	3,310	1,730	1,330	1,300	1,340	1,260
A	Brown ..	94	108	71*	31	42	42	27
	Bont ..	12	34	25	—	—	—	—
	Total ..	106	142	96	31	42	42	27
B	Brown ..	56	157	67	22	45	33	39
	Bont ..	31	50	23	—	—	—	—
	Total ..	87	207	90	22	45	33	39

*Includes 1 *Boophilus.*

NOTE.—During the above tick collections no Bont ticks were at any time collected from the ears or tail, and no Brown ticks from the body. All the Brown ticks collected from herds A and B after dipping at 1 in 300 came from the ears. On two separate occasions a single *Boophilus* tick was collected, otherwise only Brown and Bont ticks were found.

TABLE X

LOSS OF ZONDAGAM IN DIP

Date	Additions to dip		Cattle dipped	Volume lost	Gamma content	Zondagam	
	Water	Zondagam				Content	Lost
	Gallons	Gallons		Gallons	p.p.m.	Gallons	Gallons
Strength of 1 in 500.							
April 22	4,090	8·5	—	—	50·5	8·2	—
23	—	—	89	30	50·5	8·2	—
May 21	—	—	445	210	49·5	7·7	0·5
June 11	—	—	710	390	48·0	7·1	1·1
Strength of 1 in 400.							
June 17	510	3·5	—	—	64·0	10·7	—
18	—	—	87	30	63·5	10·6	0·1
July 16	—	—	832	360	63·5	9·7	1·0
August 6	—	—	1,171	570	61·0	9·0	1·7
Srtength of 1 in 300.							
August 12	540	6·0	—	—	87·5	14·5	—
13	—	—	125	30	87·0	14·4	0·1
September 10	—	—	1,135	480	84·5	12·5	2·0
October 1	—	—	1,745	810	83·0	11·2	3·3
October 7	780	3·0	—	—	85·5	14·1	—
8	—	—	160	30	85·0	14·0	0·1
November 5	—	—	743	390	82·0	12·3	1·8
November 11	240	1·0	—	—	83·0	13·3	—
12	—	—	86	60	83·0	13·2	0·1
December 10	—	—	430	340	81·5	11·9	1·4
January 7	—	—	797	720	80·5	10·6	2·7

TABLE XI
Preferential Removal of Zondagam from Kibigori Dip

Date Group	22/4 to 11/6	17/6 to 6/8	12/8 to 1/10	7/10 to 5/11	11/11 to 7/1	Total
	Gallons	Gallons	Gallons	Gallons	Gallons	Gallons
Total loss	1·1	1·7	3·3	1·8	2·7	10·6
Mechanical loss	0·8	1·4	2·75	1·5	2·35	8·8
Preferential removal ..	0·3	0·3	0·55	0·3	0·35	1·8
P.R. per 1,000	0·4	0·25	0·3	0·4	0·45	0·35

TABLE XII
Wash Dripping off Animals

	A	B	C
	p.p.m.	p.p.m.	p.p.m.
Gamma content of wash ..	49·5	63·5	81·5
Gamma content of drippings ..	46·5	60·5	78·0
Difference	—3·0	—3·0	—3·5

TABLE XIII
Preferential Removal in Sheep Dip
Gamma content

Wash	At start	At finish	Per cent loss
	p.p.m.	p.p.m.	
"Kabete" miscible oil	80	78	2·5
Zondagam emulsion	98	78	18·4
Gamatox 2 paste	66	26	60·6
Local dispersible powder ..	110	25	77·3

TABLE XIV
Percentage Ticks Dead on Gammexane-Fed Rabbits

Dead after	Rabbit No. 1		Rabbit No. 2		Control	
	Male	Female	Male	Female	Male	Female
days	per cent	per cent	per cent	per cent	per cent	per cent
1	—	40	—	30	—	—
2	60	70	50	70	—	—
3	90	100	80	100	—	—
4	100	100	100	100	—	—

TABLE XV

TICK MORTALITY RECORDED DAILY WITH SHEEP FED ON GAMMEXANE

Sheep	No. 1		No. 2		No. 3		No. 4		No. 5		No. 6		No. 7		No. 8	
Ear	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R
After 1 day	—	—	—	—	1	2	1	1	4	2	6	4	—	—	—	1
„ 2 days	1	2	1	2	2	3	4	6	5	6	8	6	—	—	—	1
„ 3 „	2	2	3	3	4	4	4	6	5	6	8	8	—	—	—	1
„ 4 „	2	4	3	4	4	4	5	7	7	8	9	8	—	—	—	1
„ 5 „	3	4	5	6	6	5	5	7	8	8	10	8	—	—	—	2
„ 6 „	4	5	5	6	6	6	6	8	8	8	10	8	1	—	—	2
„ 7 „	5	6	6	7	6	6	6	8	8	8	10	8	1	—	—	2
„ 8 „	5	6	6	7	7	7	6	8	8	8	10	8	2	2	—	2
„ 9 „	6	7	6	7	7	7	6	8	8	8	10	9	2	2	1	2
„ 10 „	6	7	7	7	7	8	6	9	8	8	10	9	2	2	1	2
Per cent kill	65		70		75		75		80		95		20		15	

TABLE XVI

NUMBER OF DAYS WITH 100 PER CENT TICK MORTALITY ON GAMMEXANE-FED OXEN

	Cattle					
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Dose	30 mg.		30+30 mg.		30+30+30 mg.	
No. of days	10	8	18	16	22	24
Average	9		17		23	

TABLE XVII

PREFERENTIAL REMOVAL FROM GAMATOX LIQUID STOCK DIP

No. of cattle	Loss of liquid stock, in gallons				Gamma Content
	Total	Mechanical	Preferential removal	P.R. per 1,000 cattle	p.p.m.
847	4·3	0·7	3·6	4·2	60·8
1,195	5·9	0·9	5·0	4·2	41·3
1,967	7·6	1·7	5·9	3·0	64·9
2,217	8·5	1·9	6·6	3·0	58·6
2,418	10·3	2·3	8·0	3·3	119·0
2,557	11·7	2·6	9·1	3·5	108·0
3,160	14·2	3·6	10·6	3·4	95·0
4,616	22·4	6·8	15·6	3·4	121·3
5,237	24·5	7·5	17·0	3·3	105·5
5,738	26·6	8·3	18·3	3·2	147·3
6,803	33·0	11·0	22·0	3·3	125·0

TABLE XVIII

GAMATOX LIQUID STOCK DIP

	p.p.m.
Wash in tank	109·2
Dripping from cattle	79·7
Returning to sump	73·9
Returning to dip	65·2

TABLE XIX

NUMBER OF TICKS ALIVE ON TEN CATTLE

DATE	CONTROL		DIPPED		Gamma Content in p.p.m.
	Before	24 hours after	Before	24 hours after	
26th November	66	66	47	29	50·0
3rd December	82	80	17	4	50·0
10th December	39	28	7	5	49·5
17th December	28	31	16	4	49·5
24th December	28	26	18	5	49·0
7th January ..	32	33	31	17	62·5
14th January ..	32	30	26	10	60·0
21st January ..	26	22	23	9	56·8
28th January ..	26	20	21	8	55·5
11th February ..	33	30	50	8	62·0
18th February ..	29	25	19	5	58·1
25th February ..	22	30	6	1	56·8
3rd March ..	29	36	11	1	54·5
10th March ..	31	31	16	4	52·1
24th March ..	61	71	24	4	81·4
31st March ..	29	25	16	6	75·5
7th April ..	23	33	20	4	70·1
14th April ..	19	27	11	2	66·5

VEGETABLE FIBRES AND FLOSSES IN EAST AFRICA

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(*Received for publication on 15th September*, 1949)

A descriptive list has been prepared which contains the names of some 250 indigenous and exotic plants in East Africa which are of commercial value or of some use to the natives as fibre or flosses.

It is not proposed to include descriptions of all of them in the present paper but only the more important and immediately or easily obtained ones.

In Part I, I have grouped the majority of the species under their various most important uses. Those shown in brackets, thus: [ ], are exotics, whether in commercial production or only represented by small experimental plantings at Amani or elsewhere.

The majority of the species in Part I are, however, from the rough nature of their products, their scattered occurrence or the difficulty of their preparation, not likely to be of value as commercial fibres or flosses. Those plants which do not fall into this low-value category are marked with an asterisk * and notes on some of the more important species are provided in Part II.

In Part II the genera and species are listed alphabetically under both botanical and common names; and an indication is usually given of the part of the plant from which its product is obtained, the method of preparation, its more important uses, and its frequency. Its distribution in the British Territories in East Africa is indicated by U=Uganda, K=Kenya Colony, T=Tanganyika, Z=Zanzibar including Pemba, N=Nyasaland and N.R.=Northern Rhodesia. A question mark indicates that the plant has still to be recorded in an area where one would expect to find it. Exotics are shown in brackets, thus: [ ].

PART I

BRUSH FIBRES

[Agave heteracantha]
[A. lophantha]
[Attalea funifera]
Elæis guineensis
Oryza sativa
[Yucca spp.]

Brooms

*Cocos nucifera
Panicum maximum
*Phragmites communis
*P. mauritianus
*Raphia spp.
Sida acuta
S. alba
S. cordifolia
S. rhombifolia
Smithia speciosa
[*Sorghum dochna var. technicum]
Tacca involucrata
[Thysanolæna maxima]
Wissadula amplissima var. rostrata

Brushes

Aloe spp.
[Arenga pinnata]
*Borassus æthiopium
Elæis guineensis
Hibiscus micranthus
*Hyphæne spp.
*Raphia spp.
[*Sorghum dochna var. technicum]

Tooth-brushes and Chewing Sticks

Clausena anisata
Craterispermum laurinum
*Dobera loranthifolia
*D. roxburghii
Dracæna usambarensis
Elæis guineensis
Euclea bilocularis
Glyphæa laterifolia
Rhus incana
*Salvadora persica
Sida acuta
S. rhombifolia
*Vellozia spp.

CORD AND CORDAGE

Adansonia digitata
[Arenga pinnata]
Bauhinia thonningii
*Brachystegia randii
*Calotropis syriaca (Syn. *C. procera*)
*Cannabis sativa
Chlorocodon whiteii
*Cocos nucifera
Cordia gharaf
[C. myxa]
[*Crotalaria juncea]
C. retusa
C. striata
Dombeya mastersii
D. nairobensis
Elæis guineensis
Ensete edule (Syn. *Musa ensete*)
Entada phaseoloides
E. sudanica
*Ficus natalensis
*F. platyphylla
[*Furcræa gigantea]
Grewia mollis
Hexalobus monopetalus
*Hibiscus cannabinus

H. panduriformis
H. tiliaceus
Lannea barteri
Lasiosiphon lampranthus
[*Musa textilis]
Pavonia schimperiana
[Phormium tenax]
Rytigynia neglecta
*Sansevieria spp.
*Thespesia populnea
Triumfetta bartramia
T. tomentosa
*Urena lobata
Vigna unguiculata var. textilis

Fishing Lines

*Ananas comosus
*Calotropis syriaca (Syn. *C. procera*)
Caperonia palustris
*Crotalaria striata
Elæis guineensis
Hibiscus aspera
H. esculentus
H. micranthus
[*Linum usitatissimum]
Pergularia extensa
Sida rhombifolia
*Urena lobata
Vigna unguiculata var. textilis

Ropes

[Abroma augusta]
[*Agave amaniensis]
[A. fourcroydes]
[*A. sisalana]
[Arenga pinnata]
*Borassus æthiopium
*Brachystegia taxifolia
*Cannabis sativa
*Cocos nucifera
*Crotalaria retusa
Dombeya rotundifolia
Entada phaseoloides
*Ficus petersii
Glyphæa laterifolia
Grewia bicolor
G. forbesii
G. holstii
Hibiscus tiliaceus
Isoberlinia globiflora
*Lasiosiphon lampranthus
Phoenix dactylifera
Rytigynia sp.
*Sansevieria cylindrica
*S. ehrenbergii
*S. robusta
Securidaca longipedunculata
Sesbania bispinosa
S. sesban
Sterculia africana
S. leguminosaceæ
S. rhyncocarpa
Tamarindus indica
Uvaria sp.
Vigna schimperi

String

Abutilon usambarensis
Bidens magnifolia
Cissampelos pariera
*Crotalaria intermedia
Elæis guineensis
Grewia bicolor
G. forbesii
G. holstii
Juncellus lævigatus
Rhynchospora corymbosa
*Sansevieria robusta
*Sansevieria spp.
Securidaca longipedunculata
Tamarindus indica
Trema guineensis
Triumfetta bartramia
T. macrophylla
Vigna schimperi
V. unguiculata var. textilis

Thread

*Ananas comosus
[Arenga pinnata]
Fleurya æstuans
[*Linum usitatissimum]

Twine

[*Agave amaniensis]
[A. fourcroydes]
[*A. sisalana]
*Ananas comosus
*Borassus æthiopium
*Cannabis sativa
Corchorus capsularis
C. olitorius
Elæis guineensis
[*Furcræa gigantea]
Hexalobus monopetalus
[*Linum usitatissimum]
[*Musa textilis]

Other Tying Materials

Abutilon mauritianum
Barringtonia racemosa
Bauhinia thonningii
*Brachystegia spp.
Calamus asperrimus
Callopsis volkensii
Cissampelos pariera
Clematis simensis
[Cochlospermum gossypium]
Cordia holstii
Culcasia scandens
Cyperus immensus
Dombeya cincinnata
Entada sudanica
Harungana madagascariensis
Hibiscus tiliaceus
Lannea barteri
Metaporana densiflora
Parkia filicoidea
Paullinia pinnata
Periploca linearifolia
*Raphia mombuttorum
*R. ruffia
Stephania sp.
Sterculia africana
Stictocardia laxiflora
Triclisia sacleuxii
Triumfetta tomentosa
Uvaria sp.

FABRICS

Adansonia digitata
*Ficus platyphylla
*Urena lobata

Bags, Bagging or Sacking
Abutilon usambarensis
[*Agave sisalana]
*Brachystegia randii
*Cannabis sativa
Corchorus capsularis
C. olitorius
[*Crotalaria juncea]
*C. striata
Dichrostachys glomerata
Dombeya nairobensis
[*Furcræa gigantea]
[*Musa textilis]
*Sansevieria robusta
*Sansevieria spp.

Bark-cloth
Adansonia digitata
*Brachystegia boehmii
*B. edulis
*B. randii
*Ficus spp.
Isoberlinia globiflora

Canvas
[*Crotalaria juncea]
*C. retusa
*Hibiscus cannabinus
[*Linum usitatissimum]

Carpets
*Cannabis sativa
Corchorus capsularis
C. olitorius
[*Linum usitatissimum]

Cloth
*Ananas comosus
Bauhinia thonningii
*Cannabis sativa
Corchorus capsularis
C. olitorius
Elæis guineensis
Ensete edule (Syn. *Musa ensete*)
*Ficus spp.
*Gossypium spp.
[*Linum usitatissimum]
[*Musa textilis]
[Phormium tenax]
Securidaca longipedunculata
Vigna unguiculata var. textilis

Webbing
*Cannabis sativa

NETS AND NETTING

[*Abroma augusta]
[*Agave sisalana]
*Asclepias semilunata
*Calotropis syriaca (Syn. *C. procera*)
[*Crotalaria juncea]
*C. retusa
*C. striata
Cyperus papyrus
Entada phaseoloides
Hibiscus esculentus
H. tiliaceus
Pachyrrhizus erosus
*Poulzolzia hypoleuca
Securidaca longipedunculata
Sida rhombifolia
*Thespesia populnea
Typhonodorum lindleyanum
Vigna unguiculata var. textilis

Hammocks
[Abroma augusta]
Hibiscus esculentus
[*Furcræa gigantea]

PAPER

This list would have been much longer if I had included all the plants that have possibilities as paper-making materials, but it has been included as most of those listed here are only by-products of other fibres.

*Borassus æthiopium
*Cannabis sativa
Corchorus capsularis
C. olitorius
Desmodium gangeticum
Hibiscus sabadariffa var. altissima
[*Linum usitatissimum]
[Morus alba]
[M. indica]
[*Musa textilis]
Oryza sativa
[Parkinsonia aculeata]
Ricinus communis
Sporobolus pyramidalis
*Typha spp.
*Urena lobata

PLAITING AND WEAVING

*Borassus æthiopium
Celtis integrifolia
*Crotalaria spp.
*Cyperus spp.
Dracæna spp.
Elæis guineensis
Eleocharis spp.
Eragrostis spp.
Flagellaria guineensis
*Hyphæne spp.
Juncus spp.
Oryza sativa
Pennisetum purpureum
[Sechium edule]
Smilax kraussiana
Sporobolus spp.
Triumfetta bartramia
*Typha spp.

Baskets and Basketwork
*Borassus æthiopium
[Calamus spp.]
*Cocculus hirsutus
*Cocos nucifera
*Crotalaria spp.
Cyperus alternifolius var. flabelliformis
C. maranguensis
Dichrostachys glomerata
Eleusine indica
Oreobambos buchwaldii
Oxytenanthera spp.
Pandanus spp.
*Phœnix reclinata
*Raphia mombuttorum
*R. ruffia
*Smilax kraussiana
Sporobolus pyramidalis

Hats

*Borassus æthiopium
[Carludovica palmata]
*Cocos nucifera
Luffa cylindrica
[*Musa textilis]
*Sansevieria spp.

Mats and Matting

*Borassus æthiopium
Clappertonia ficifolia
*Cocos nucifera
Cyperus alternifolius var. flabelliformis
C. articulatus
C. haspan
C. papyrus
Pandanus spp.
Pennisetum purpureum
Phœnix dactylifera
*P. reclinata
[Phormium tenax]
*Phragmites communis
*P. mauritianus
Pycreus umbrosus
*Raphia mombuttorum
*R. ruffia
*Sansevieria spp.
*Scirpus corymbosus
Sterculia africana
Torulinium confertum

Stuffing Materials, Including Flosses

*Asclepias spp.
*Bambusa sp.
*[Bombax malabaricum]
*B. reflexum
*B. rhodognaphalon
*B. stolzii
*Calotropis syriaca (Syn. *C. procera*)
*Cannabis sativa
*Ceiba pentandra
Chlorocodon whiteii
[Cochlospermum gossypium]
Cryptolepis oblongifolia
*Gossypium spp.
*Raphia spp.
*Typha spp.

Thatches and Thatching Materials

[Arenga pinnata]
*Borassus æthiopium
Calamus spp.
*Cocos nucifera
Cyperus immensus
C. papyrus
*Hyphæne spp.
Pandanus spp.
*Phragmites communis
*P. mauritianus

PART II

Abaca, *see Musa.*

African Fan Palm, *see Borassus æthiopium.*

[AGAVE L. Agavaceæ

This exotic genus is of importance on account of the number of species the leaves of which yield commercial fibres. The brush fibres commonly known as Ixtle or Istle are obtained from the immature leaves of *A. heteracantha* Berger, *A. lophantha* Schiede (*A. Lechuguilla* Torr.) and species of *Yucca*. These are not in commercial production in East Africa.

A. amaniensis Trelease & Nowell, Blue Sisal.—Decortication; twine and rope; not extensively cultivated in U. K. T.

A. sisalana Perrine, Sisal.—Decortication; twine, rope, sacking, cultivated commercially in K. T. but found growing elsewhere in East Africa.]

ANANAS Adans. Bromeliaceæ

A. comosus Merr. Pineapple fibre.—Hand decortication of fresh leaves; leaf fibres, thread, twine, fishing lines, pineapple or grass cloth. The difficulties of extracting the fibre make it uneconomic commercially. A perennial herb cultivated and naturalized in places throughout East Africa.

ASCLEPIAS L. Asclepiadaceæ

A number of species have bast fibres which have been reported on from time to time. The fibres separate readily but it is difficult to obtain long strands of even length. On this account spinners object to using any material measuring under 3 ft. The floss from the fruits has been used for stuffing but owing to their lack of resiliency they cannot compete with Kapok.

Some genera in the Asclepiadaceæ have very strong and fine fibres but most of them contain a white latex with a high percentage of resin that retards retting and they can only be obtained by hand extraction, which is uneconomic commercially.

The fibres vary from about an inch (*Chlorocodon whiteii* Hk. f.) to five feet (*Asclepias semilunata* N.E. Br.) long. The yield is also uneconomic; 250 to 350 lb. per acre has been estimated for *A. semilunata* which also when cultivated in large numbers is peculiarly liable to insect attack which destroys the whole crop.

A. fruticosa L.—Fibre from bark; floss from seeds. The fibre contains a very large proportion of cellulose, is white, lustrous and flax-like and if obtainable in sufficient length could be spun into a yarn resembling that of flax or ramie. The floss has been used for stuffing but cannot compete with Kapok. A shrub up to ten feet, local but widespread throughout East Africa.

A. physocarpa Schlechter.—Fibre, bark. Tried in the Deccan, where a plot of one-twentieth acre gave 13½ lb. of a pure white fibre, which however could not be peeled off satisfactorily and broke off in small bits. A perennial herb locally distributed in U. K. T.

A. semilunata N.E. Br.—Fibre bark; floss from seeds. The fibre contains a high percentage of cellulose, varies in colour from white to pale brown, in length from three to five feet, is of good lustre and fair strength and thought suitable for rough textiles. Used for fishing nets on Lake Tanganyika. Floss used in Uganda for stuffing. An annual herb locally common and sometimes cultivated in small patches in U. K. T.

Bamboo, *see Bambusa*

BAMBUSA Schreb. Gramineæ

In Eastern Java there is a substitute for piassava fibre which the trade calls "scarps". The preparation is a domestic industry; an old bamboo has its surface scraped off and is split into very fine fibre which may be dyed. The Chinese stuff pillows with it and it is said that it was used for caulking the seams of big boats. *B. vulgaris* Schrad. Golden or Feathery Bamboo is cultivated and naturalized along the coast K. T. Z. N. The indigenous *Arundinaria, Oreobambos* and *Oxytenanthera* spp. may have a similar use; the latter two are used in basket work.

Banana fibre, *see Musa*

Blue sisal, *see Agave amaniensis*

[BŒHMERIA Jacq. Urticaceæ

The bast fibre Ramie, Rhea or China Grass, is obtained from *B. nivea* Gaud. of which there are two varieties, *nivea* and *tenacissima*, with races some of which give a little more fibre than others.

The fibre contains a pectic substance which holds the strands together, is not easily broken up by bacteria in retting but is removed by "degumming".

Many attempts have been made in the past to grow this plant on a commercial scale but they have invariably been abandoned owing to the difficulty of cleaning the fibre by machinery or chemically as a process had not been evolved. Ramie spinners are not disposed to purchase supplies except in the form of hand cleaned Ramie prepared in China, where the bulk of the fibre is obtained. There it is grown as a homestead crop in small patches and the preparation of the fibre by hand is a domestic industry.

Ramie is the strongest fibre known, too good for everyday use; it outlasts all dyes and for clothing it is not fitted unless the fabric is undyed. The fibre is too harsh to take the finish of flax, the thread when spun is hairy with outstanding ends owing to the stiffness of the fibres, and it is too unlike other fibres to be mixed with them. Its chief use has been the manufacture of gas-mantles, but the demand has been very limited. A perennial shrubby herb cultivated at various times in East Africa. It requires a rich soil if its cultivation as a fibre crop is to be successful. (*See also East Afr. Agric. J.*, Vols. 2, p. 74 (1936), 3, p. 404 (1938) and 4, p. 73 (1938).)]

Bombax L. Bombaceæ

B. rhodognaphalon K. Schum.—Brown floss surrounding the seeds used by the coastal peoples for stuffing. A tree common in some coastal districts, K. T. Z.?

B. reflexum Sprague.—Floss surrounding the seeds used for stuffing. An uncommon tree, U.

B. stolzii Ulbr.—Floss surrounding the seeds; said to be used for cotton. A tree N. T. (S.W.).

BORASSUS L. Palmæ

B. æthiopium Mart. (syn. *B. flabellifera* L. var. *æthiopium* Mart.); African Fan Palm; Deleb Palm; Palmyra Palm.—Fibre, leaves, stems and fruits. Leaf segments are used for thatching, mat making, hats, fans, baskets, and buckets. Five kinds of fibre can be obtained from the palm; a loose fibre which surrounds the base of the leaf stalk; a fibre which may be separated from the leaf stalk; a fibre from the interior of the stem; a coir from the pericarp; and the fibrous material of the leaves. The stiffer types of Palmyra fibres are classed as Piassava fibres in the brush trade. Palmyra fibres are made into rope, twine, paper and machine brushes. A palm sometimes scattered but usually locally gregarious throughout East Africa, not above 4,000 ft. alt.

Bow-string Hemp, *see Sansevieria*

BRACHYSTEGIA Benth. Cæsalpiniaceæ

Various species of this genus provide from the bark a strong bast which is one of the most important native tying materials. The following species all occur in T. N. N. R. as deciduous trees in "miyombo" woodland.

B. bœhmii Taub. (syn. *B. flagristipulata* Taub.).—Used for bark cloth.

B. edulis Hutch. & B. Davy.—Used for bark cloth.

B. floribunda Benth.—Used for lashings.

B. randii Bak. f.—Much used for bark cloth, cord, bags, etc.

B. taxifolia Harms.—The bark is used as a substitute for rope in hut building. (*N.B.*—Not deciduous—P. J. G.)

B. woodiana Harms.—In Nyasaland said to be the best for many native uses.

Broom Corn, *see Sorghum dochna* var. *technicus*

Bulrush, *see Typha*

CALOTROPIS R. Br. Asclepiadaceæ

C. syriaca (S.G. Gmel.) Woodson (Syn. *C. procera* Ait.).—Fibre, bast; floss from seeds. From the inner bast a glossy flax-like fibre is obtained, but is costly to produce. It cannot be obtained by retting owing to the latex. In N. Nigeria it is extracted by maceration for three days and separation by hand and is difficult to extract as the fibres come away in short strands. It provides strong cordage and is used for fishing lines and nets by various tribes. The floss is used for stuffing but cannot compete commercially with Kapok as the silky hairs are not resilient. *C. gigantea* (Willd.) R. Br. has a similar fibre and floss. It is an Asiatic shrub or small tree said to be found in Nyasaland but it is probably confused with *C. syriaca*. A shrub frequently seen in native settlements in the drier parts of East Africa.

CANNABIS L. Cannabinaceæ

The term hemp is applied loosely in commerce but true hemp is the bast of *Cannabis sativa* L. Hemp is white and is valuable because of its length, varying from three to nine feet, strong and of great durability. It is not flexible and elastic like flax because its fibres are somewhat lignified. It is used for ropes, twine, carpets, sailcloth, yacht cordage, binder twine, sacks, bags and webbing. Hemp waste is sometimes used in paper making. The short fibres or tow and waste are called oakum.

C. sativa is a branching annual from 5 to 15 ft. tall. The plants are harvested into bundles and dried and the fibres are obtained by water or dew retting the stems, which are then broken, scutched and hackled by hand. *C. sativa* is found as a weed throughout East Africa, its cultivation being illegal as it is also the source of a narcotic drug.

CEIBA Mill. Bombacaceæ

The floss, Kapok, is the silky springy hairs which are attached to the seeds of *C. pentandra* Gærtn., a tree attaining a height of 90 ft. Kapok is an outstanding silk cotton, the most valuable of all the stuffing materials, and its use is steadily increasing. The fibres have a low specific gravity and are impervious to water and on this account are most valuable for life-saving equipment. There is a reddish fibre in the bark which is not commercially exploited. A tree cultivated and naturalized in some places in East Africa. (*See also East Afr. Agr. J.*, Vol. 3, p. 440 (1938).)

China Grass, *see Bœhmeria nivea*

Cocculus DC. Menispermaceæ

C. hirsutus (L.) Diels.—The cortex of the thin and very pliable stems makes excellent weaving material used by the natives on the western shores of Lake Nyasa for making cane furniture for European houses. A perennial scandent shrubby herb, locally common in dry areas U.? K.? T. N. N.R.?

COCOS L. Palmæ

From the husks of the fruits of the coconut, *C. nucifera* L., Coir is obtained. The preparation of the fibre is a domestic industry in East Africa, by rotting in pits around the margins of mangrove swamps where the pits are covered by sea water at each high tide. A nut 10 or 11 months old is said to yield the best fibre; if younger it is weak, if older gives a harsh and coarse fibre. Coir is used for matting and cordage, the latter having a useful elasticity, it does not break so suddenly as ropes of some stronger fibres but it lacks strength and on this account can never command a very wide market. Coconut palm leaves are used for thatching, fencing, mats, brooms, baskets and hats and there is a fairly strong white fibre in the leaf stalks which are also surrounded by a pale to dark brown fibrous mass. A palm cultivated in the coastal districts but sometimes found inland U. K. T. Z.

Coir, *see Borassus æthiopium*, *Cocos nucifera*.

Cotton, *see Gossypium*.

CROTALARIA L. Papilionaceæ

Sunn Hemp, an important Asiatic fibre, is obtained from *Crotalaria juncea* L. It is a shrubby annual from 6 to 10 ft. high extensively grown in India. The bast is the source of its fibre which is stronger, lighter in colour and more durable than Jute. It is used for cordage, sacks, nets and coarse canvas.

Dale (*Trees and Shrubs of Kenya Colony*, p. 73) states that "Crotalarias all produce a fibre of varying degrees of strength, the herbaceous species as a general rule produce the strongest fibre, and they are used by the Akikuyu for basket weaving".

C. intermedia Kotschy.—Fibre. In the Eastern Sudan a strong string is made out of its fibres. A rather variable annual herb up to 5 ft. tall, local but widespread U. K. T. N. N.R.?

[*C. juncea* L. Sunn Hemp.—Fibre, bast. Annual shrubby herb to 10 ft. Cultivated throughout East Africa as a green manure and cover crop.]

C. retusa L.—Fibre, bast. In India cultivated and fibre extracted which is classed as a sort of Sunn Hemp and used for cordage, canvas, etc. In the Eastern Sudan the fibre is used for rope and nets. A much-branched annual to 3 ft., local but widespread in East Africa, especially down the coast.

C. striata DC.—Fibre, bast. Cultivated in India and South Africa for a fibre, occasionally called Sunn Hemp, with which it is almost identical, suitable for cordage, fishing nets and lines, sacking, etc. In the Sudan it is used for game nets. A much-branched shrubby annual to 6 ft. locally common throughout East Africa.

CYPERUS L. Cyperaceæ (Sedges)

Leaves or stems of members of this genus are put to a variety of uses, for thatching, plaiting and rough weaving. They are annual or perennial herbs from a few inches up to 20 ft. in height, many aquatic or semi-aquatic, others found in very dry country where they are mostly ephemerals.

Deccan Hemp, *see Hibiscus*.

Deleb Palm, *see Borassus æthiopium*.

DOBERA Juss. Salvadoraceæ

D. loranthifolia Warb. and *D. roxburghii* Planch.—Fibrous branches used as tooth brushes or chew sticks. Much-branched trees to 30 ft. tall, very local in the coastal districts K.T.

Doum or Dom Palm, *see Hyphæne*.

Ensete (*see Musa*).

FICUS L. Moraceæ

This genus was of importance to the natives as one of the chief sources of bark cloth for clothing and blankets. A modern use might be as insulating material.

F. glumosa Del. var. *glaberrima* Martelli.—In the Eastern Sudan the bark is used for making cloth. A large tree. U.

F. kitubolu Hutch.—Yields an inferior type of bark cloth. A spreading tree up to 30 or more feet high. U.

F. natalensis Hochst.—In Uganda it furnishes a very good bark cloth and an account of its mode of preparation is given by Eggeling. In Portuguese East Africa a coarse cordage is also obtained from the bark. An evergreen tree up to 40 ft. tall, locally common throughout East Africa.

F. petersii Warb.—The bast is made into rope. A much-branched tree to 60 ft., local in K.? T. N. N.R.?

F. platyphylla Del.—The bark yields a fibre used for indifferent cordage and for weaving into fabrics. A tree to 60 ft. tall. U.

F. thonningii Blume.—The bast gives a bark cloth which is prepared in the same way as *F. natalensis*. An evergreen tree to about 40 ft. tall, widespread throughout East Africa.

Flax, *see Linum*.

FUNTUMIA Stapf Apocynaceæ

F. elastica (Preuss.) Stapf, Lagos Silk-rubber tree.—Floss, attached to the seeds. Used as a stuffing material but cannot compete with Kapok. The floss is capable of being spun. A tree to 80 ft. tall in rain forest, U. Cultivated, T.

F. latifolia (Stapf) stapf ex Schlecht.—Floss, attached to the seeds. Used as a stuffing material by the natives. A rain forest tree up to 60 ft. tall. U. K. T.

[FURCRÆA Vent. Agavaceæ

Mauritius Hemp, sometimes known as Pita Fibre, derived from the leaves of *F. gigantea* Vent., has been grown in East Africa from time to time, is now found as an escape near habitations throughout East Africa and is used by the natives for a variety of purposes where cordage is required. It is grown commercially only in Mauritius and St. Helena. The fibres are very long, white, soft and elastic but are weaker than sisal. They are used alone or mixed for making hammocks, bags, coarse twine and other small cordage.]

GOSSYPIUM L. Malvaceæ

The fine fibrous hairs that occur on the seeds of species of this genus constitute Cotton. It is the world's greatest industrial crop, the chief fibre plant and one of the oldest as well as the cheapest. Several species as well as numerous races are cultivated for cotton. There are also one or two wild species in East Africa whose seeds are covered by a floss but these are very local and their fibres are poor and only used as a stuffing material.

Hemp, *see Cannabis sativa.*

HIBISCUS L. Malvaceæ

This genus contains a number of species which yield fibres, the most important being Deccan Hemp, *H. cannabinus* L., an important fibre crop in India and used as a substitute for hemp and jute in the making of cordage and coarse canvas. It is widespread and often cultivated in places throughout East Africa.

HYPHÆNE Gærtn. Palmæ

Doum or Dom Palm leaves are used for thatching and they are sources of leaf fibres used for brushes and for plaiting work. In some species the base of the leaf stalk has scattered black or dark brown fibres which, unfortunately are not long as they are branched. They are hard and are suitable for brushware but their commercial exploitation will depend upon the ease and cost with which they can be extracted from the very hard leaf stalks. Eight species are recorded in East Africa most of them in Tanganyika.

LASIOSIPHON Fres. Thymelæaceæ

L. glaucus Fres.—Fibre, bark. A much-branched tree up to 40 ft. tall, sometimes locally dominant in secondary forest. U. K. T. N. N.R.

L. lampranthus (Gilg) Gilg.—Fibre, inner bark. A white fibre of local value in Uganda for cord and rope making. A much-branched tree to 15 ft., local at high altitudes. U. K. T.

[LINUM L. Linaceæ

Flax fibres from the stems of *Linum usitatissimum* L., consist of very tough, stringy strands from 1 to 3 ft. long and are aggregates of many long-pointed cells with very thick cellulose walls. The fibres are obtained by a series of operations known as rippling, water or dew retting and scutching. Flax fibres are of value for their durability, length of staple and their great tensile strength. They are used in the manufacture of linen cloth and thread, canvas, duck, carpets, the strongest twine, the best fish and seine lines, the finest writing paper, and insulating materials. There are a number of races, some grown for the fibre, other for linseed. Cultivated to a greater or lesser extent in U. K. T. N. N.R.]

Manila Hemp, *see Musa.*

Mauritius Hemp, *see Furcræa gigantea.*

MUSA L. Musaceæ

Most of the species of this genus yield fibres which are obtained from their leaf stalks, which form the so-called trunk of the Banana and Plantain. The most important is Abaca or Manila Hemp, obtained from races of *Musa textilis* Nee. Manila hemp fibres vary in colour from white to reddish yellow, are very light, stiff and lustrous; they consist of a series of structural cells and are removed from the leaf stalks by hand. The fibres vary from 6 to 12 in. in length, are very elastic and amongst the strongest known. Manila hemp is used mainly in the manufacture of cordage, especially for marine purposes as the fibre is not injured by salt or fresh water. Binder twine, bagging, papier mâché, wrapping paper, hats and a lustrous cloth known as sinamay cloth are other uses to which the fibre is put.

Specimens of *Musa* (= *Ensete*) fibre, thought to be *Ensete livingstonianum* (Kirk) Cheesman (Syn. *M. livingstoniana*), have been submitted to the Imperial Institute, from time to time from Kenya and have been favourably reported upon. The fibre from about five other species including a plantain is used by the natives. The dried leaf-stalks are used as a tying material by the natives and for thatching.

Palmyra Palm, *see Borassus æthiopium.*

Phœnix L. Palmæ

P. reclinata Jacq. Wild Date Palm.—Leaves used for matting, screens and basket work. A palm branching at ground level and the stems attaining a height of 30 ft. Locally common, especially in swampy areas throughout East Africa, and one of the most important materials to the coastal peoples.

PHRAGMITES Trin. Gramineæ

P. communis Trin. and *P. mauritianus* Kunth, Reed-grass.—Stems and leaves used for matting, plaiting and thatching, the inflorescence for soft brooms. Reed grasses up to 20 or more feet tall. The former is recorded from K. and N.R. the latter is common in swamps and slow rivers throughout East Africa.

Piassava fibre, *see Borassus æthiopium* and *Raphia.*

Pineapple fibre, *see Ananas comosus.*

Pita fibre, *see Furcræa gigantea.*

Plaintain fibre, *see Musa.*

POULZOLZIA Gaudich. Urticaceæ

P. hypoleuca Wedd.—Fibre, stems. Said to make durable fishing nets. A perennial shrubby herb up to 7 ft. tall commonly cultivated around Lake Nyasa. T. N. N.R.?

Raffia Palm, *see Raphia monbuttorum and R. ruffia.*

Ramie, *see Bœhmeria nivea.*

RAPHIA Beauv. Palmæ

One of the sources of Piassava fibre is a *Raphia* which passes under the name of *R. vinifera* P. Beauv. in West Africa, but it is probable that other species are involved. The fibre consists of the vascular bundles of the leaf sheaths and lower part of the petioles. It is obtained by retting in running water, then beating and combing. It is used for brooms, brushes and mats. Piassava Tow is the waste matter and pith extracted in cleaning, a fibrous mass resembling coir for which it is a substitute, or as a cheap upholstery material. Raphia or raffia fibre obtained from the young unexpanded leaves is another product used principally as a tying material in nurseries and gardens.

About six species have been recorded from East Africa and except for the following two most of them are found in northern Northern Rhodesia and south of Lake Nyasa in Nyasaland.

R. mombuttorum Drude. Raffia Palm.—Fibre, the young unexpanded leaves. Used for tying, mat and basket work. Very local U. K.? T.?

R. ruffia Mart. Raffia Palm.—Fibre, the young unexpanded leaves. Used for tying, mat and basket work. Native of Madagascar, where a wax is obtained from the leaf surfaces. A palm passing under this name and from which a wax can be obtained is found in swamps in K. T. Z.

Rhea, *see Bœhmeria nivea.*

SALVADORA Garcin. Salvadoraceæ

S. persica Garcin. Tooth-brush Tree.—Stems and branches used as toothbrushes or chewing sticks. A much-branched evergreen tree or shrub, locally dominant on saline soils. U.? K. T. Z.? N. N.R.

SANSEVIERIA Thunb. Agavaceæ

Twenty-five species of this genus have been recorded in East Africa, some of them are sources of Bow String Hemp, a strong white or cream elastic fibre, which has long been used by the natives for mats, hats, bags, bow-strings and other types of crude cordage. Their exploitation from the wilds has been attempted from time to time without much success as they have to compete with other fibres which come onto the market regularly. (*See also East Afr. Agr. J.* Vol. 7, p. 96 (1941).)

S. cylindrica Boj.—Used for making rope, etc. Perennial herb with 3–6 leaves up to 5 ft. long. Angola, probably in N.R.

S. dawei Stapf. Tuor Fibre.—Perennial herb with 2–3 leaves up to 5 ft. long. U.K.?

S. ehrenbergii Schweinfurth ex Bak.—Used for making rope. Perennial herb with 5–9 leaves to a growth up to 6 ft. long. Nubia and Somaliland. K.? T.?

S. kirkii Baker.—Yields a strong fibre. A perennial herb with 1–3 leaves to a growth up to 9 ft. long. Locally common in the E. Usambaras. T. and Z.

S. raffellii N.E. Br.—Probably yields a fibre similar to *S. kirkii*. A perennial herb with 1–2 leaves to a growth up to 3½ ft. long; rare K.

S. robusta N.E. Br.—Fibre of good quality used for making string, rope and bags, etc. A perennial with 6–14 leaves to a growth up to 7ft. long. Locally dominant K. T. Often confused with the Nubian, Eritrea, *S. ehrenbergii* which it closely resembles.

SCIRPUS L. Cyperaceæ

S. corymbosus Rottb.—The long narrow cylindrical stems are used for making sleeping mats. A perennial herb up to 3 ft. tall, locally common in swamps. U.? K. T. Z. N. N.R.

Sisal, *see Agave sisalana.*

SMILAX Tourn. Smilacaceæ

S. kraussiana Meisn.—Stems used for weaving, such as basket work. A liane with stems up to 50 or 60 ft. long. Locally common, especially on the margins of forest, throughout East Africa.

[SORGHUM Mœnch. Gramineæ

S. dochna (Forssk.) Snowden var. *technicum* (Kœrn.) Snowden (syn. *S. bicolor* Mœnch. var. *technicus* Stapf), Broom Corn.—The elongated branches of the panicle are used for making brushes and brooms. An annual grass up to about about 12 ft. tall under experimental cultivation. K. T. N.R.]

Sunn Hemp, *see Crotalaria juncea.*

THESPESIA Corr. Malvaceæ

T. populnea Soland. ex Corr.—Fibre, bark; used used for cordage and for fishing nets. A shrub or small tree locally common along the sea shore. K. T. Z.

Tuor Fibre, *see Sansevieria dawei.*

TYPHA L. Typhaceæ

About five species of bulrush are recorded from East Africa. They are perennial herbs up to 12 ft. tall, found in shallow water and wet places. The silky florets of the flowering spikes are used for stuffing pillows, their stems for making screens and their leaves, which are not very fibrous, for plaiting. It has been suggested that they might be suitable for the manufacture of paper and felt.

URENA L. Malvaceæ

U. lobata L.—Fibre, bast. The fibre is obtained by retting in running water for about seven days. It is fine, soft and lustrous, suitable for cordage and coarse fabrics and is used on the coast for making fishing lines. It is similar to jute and if properly prepared is a trifle stronger than jute but cannot compete with it in jute-growing countries as its yield is smaller. It is said that a very tough paper can be made from it. Its experimental cultivation in British Guiana and Southern Rhodesia has been abandoned. An annual attaining a height of 18 ft. under ideal conditions. A locally common weed. U. K.? T. Z. N.? N.R.?

VELLOZIA Vand. Velloziaceæ

Nine species have been recorded from East Africa, most of them from Nyasaland. The stems and branches are very fibrous and are used by some tribes as toothbrushes and chew sticks. They are of little commercial importance.

Wild Date Palm, *see Phœnix reclinata.*

THE BROWN STREAK DISEASE OF CASSAVA

DISTRIBUTION, CLIMATIC EFFECTS AND DIAGNOSTIC SYMPTOMS

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INTRODUCTION

Brown streak disease of cassava (*Manihot utilissima* Pohl.) was first recorded and described by Storey in a progress report published in 1936[1]. There appear to have been no other published accounts. The Amani work up to 1936 had demonstrated that the disease was perpetuated through vegetative propagation and transmissible through grafting; and in the absence of any visible parasite the causative agent was assumed to be a virus. Later work led to a strong suspicion that a White-Fly (*Bemisia* sp.), was the vector of the virus in the field[2]; but confirmation of this had not been obtained before the late war interrupted controlled experimental studies of the disease, and it has not been possible, up to the present, to resume them. The information contained in this paper, therefore, is based mainly on field observations. A considerable amount of information relative to geographical distribution, climatic effects and symptoms of the disease has accumulated since Storey's original publication and is set out in this paper.

GEOGRAPHICAL DISTRIBUTION

Brown streak disease was first discovered in the foothills of the Eastern Usambara Mountains, Tanganyika Territory, in the vicinity of Amani and is now known to be endemic in all East African coastal cassava-growing areas from the north-east border of Kenya to the Portuguese border in the south and to spread inland, in some areas, up to an altitude of about 3,500 feet above sea-level.

Considerable quantities of cassava are grown in those parts of Uganda and Northern Rhodesia favouring cultivation of the crop. These two territories are separated from the eastern seaboard by high terrain rising to 6,000 feet and more above sea-level, but, with the exception of parts of Uganda, it is not known for certain whether the disease has spread to them.

In Uganda the position is obscure. The disease was first noticed at the Government Experiment Station at Bukalasa in 1945 and it was assumed that it was introduced in 1934 in a varietal collection sent there from Amani; this was before the disease had been recognized. Due to the great difficulty of certain diagnosis of the disease in some clones, there may have been later introductions in subsequent consignments, but there is no certainty that this did happen.

Distribution of planting material was made from this central station to the Serere Experiment Station and to outlying demonstration plots. In 1945 all these areas were inspected by officers of the Department of Agriculture and in those areas where the disease was well established complete replacement of stocks was carried out and in others repeated roguing was undertaken. The roguing campaign was not fully effective at two of the stations and in 1948-49 a strict quarantine period of six months was imposed on these followed by complete replacement of all stocks. According to latest reports from the Senior Botanist, Mr. J. D. Jameson (*in litt.* October, 1949), to whom I am indebted for the above details, the disease must now be regarded as endemic, but not an unduly serious problem, as there appears to have been very little secondary spread over the 15-year period, except at Serere and Kaberamaido. It remains to be seen whether the recent drastic action taken at these two places will result in complete elimination of the disease from the stocks being maintained there for distribution.

Conditions in those areas of Uganda situated below 3,000 feet above sea-level would appear to be well suited to the rapid and wide dissemination of the disease by the insect vector and it is difficult to understand why this has not happened.

In Nyasaland the disease is widely distributed at lower altitudes in the Southern Province, particularly towards the Portuguese border; there is thus good reason to assume that the disease is prevalent in the latter country.

According to the report of the Kizimbani Experiment Station for 1940, the disease is generally distributed throughout the Zanzibar Protectorate[3].

EFFECTS OF TEMPERATURE

Temperature has a marked effect on the severity of the disease. Storey[1] has recorded that a fall in temperature such as that normally experienced in the cool season at Amani (3,000 ft. a.s.l.), greatly augmented the effects of the disease. Less tolerant varieties died out; the more tolerant ones survived the cool season though they suffered varying degrees of die-back, but with the onset of warmer weather such plants put out new growth and at the height of the hot season even an experienced observer had difficulty in detecting signs of the disease, in some clones, by casual inspection. These observations have been repeatedly confirmed.

It thus appears that the critical temperature at which lethal effects are produced varies with individual clones. Laboratory experiments would be necessary to determine the temperature-range within which any diseased clone would be killed.

I have never found an infected plant above an altitude of 3,500 feet above sea-level but a few correspondents have sent descriptions suggestive of mild brown streak symptoms in plants grown at somewhat higher altitudes.

It would appear from the above observations that low temperatures are inimical to the survival of diseased plants.

An attempt to procure more definite information on this point was, unfortunately, vitiated by the depredations of moles. In March, 1947, cuttings from a healthy plant and cuttings from a severely diseased plant of the same clone, together with cuttings from a plant of another clone only mildly affected by the disease were sent for propagation to the Coffee Research Station, Lyamungu (4,300 ft. a.s.l.), on the slopes of Mt. Kilimanjaro. Dr. G. B. Wallace, to whom I am indebted for the observations, reported in November, 1947, that five of the six plants grown from the severely diseased clone had died during the cool season, June to September. Before the next cool season, when it was anticipated that the remaining diseased plants would succumb, a plague of moles had destroyed them all, including the healthy plants, so that the precise information hoped for from this experiment was not forthcoming.

In the absence of more exact information the critical altitude, in equatorial regions, at which even mildly diseased plants may be expected to die, due to the effects of low temperature, is tentatively put at between 3,500 and 4,500 feet above sea-level. Since temperature is the governing factor this figure would presumably be reduced progressively with increasing distance from the equator.

Dissemination of the disease, by the insect vector, at these high altitudes does not appear to take place; the reason for this is not known.

The disease is most prevalent in those cassava-growing areas ranging from sea-level to about 2,000 feet above sea-level, but it must be emphasized it is not always easy to detect infected plants in the established varieties in cultivation, without a very thorough search. This is due partly to a process of natural selection which has eliminated from cultivation the more intolerant varieties and partly to the suppressive or masking effect on symptoms, in the more tolerant varieties, due to the relatively high temperatures encountered. It is only with the introduction of highly intolerant varieties into such an endemic area that diseased plants present a striking appearance. Field trials carried out in the Tanga Province over a period of ten years, on seedling material, have afforded ample opportunity to note the great variability in the effects of the disease on different clones. This ranges from what appears to be complete field immunity, through a series showing varying degrees of susceptibility and tolerance to those which succumb.

EFFECTS ON YIELD

If yield be judged solely by the weight of roots reaped there appears to be little difference in the yields of healthy and secondarily infected plants of any given variety. For example, in a varietal disease-resistance trial in 1939 the weights of roots reaped from healthy and secondarily diseased plants showed no significant difference. (I am indebted to Dr. F. Yates, Rothamsted Experiment Station, for carrying out the analysis of this experiment. It so happens that the above and all later field disease-resistance trials have been initiated when natural infection was at its lowest and the plants had been well established before symptoms appeared; it is therefore possible that in intolerant varieties the yields of diseased plants would be significantly lower if they were planted during the peak infection period and thus became infected during the early stages of growth.

At present there are no figures available comparing the respective yields of plants grown from healthy and diseased cuttings, but, except in highly intolerant varieties in which growth of the plant is partially or totally inhibited and therefore root formation arrested, no marked reduction in yield is apparent. However, as will be shown later in this paper, notwithstanding little if any reduction in the weight of roots, the quality of diseased roots may be such as to render them of little economic value.

SYMPTOMS OF THE DISEASE

The name "Brown Streak" was given to the disease in consequence of the brown lesions which sometimes appear on the young green stem and were the first symptom of the disease to be recognized. This is somewhat unfortunate as these stem lesions are now known not to be the most characteristic symptom. The description below is an elaboration of that by Storey in 1936.

Symptoms are now recognized in leaf, stem, fruit and root and they may occur in only one organ or in two or more organs simultaneously. The presence or absence of symptoms in these organs is constant for any given clone and it therefore appears that the controlling factor in symptom expression is genetical.

Leaf Symptoms.—These are of two types; in both cases they take the form of varying degrees of chlorosis, suggesting a mosaic disease; but, and this is an important diagnostic feature, only mature or nearly mature leaves are affected. (An exception to this is when a plant is severely diseased and on the point of death.) In consequence there is *no distortion of the lamina*, whereas the common mosaic virus of cassava affects the young developing leaves causing more or less distortion as the leaves develop and imparting the characteristic crinkled appearance of mosaic-diseased plants.

Yellowing due to brown streak infection might conceivably be confused with the yellowing commonly associated with successional leaf-fall. The essential difference is that in the former case the leaf segments always show some green areas while in the latter they are uniformly yellow.

In the first type of leaf symptom (Plate 1, Fig. 1,) this leaf also shows mosaic infection), the chlorosis first appears along the margins of the secondary veins, starting from the base of the leaf segments and radiating out on either side of the primary vein. Subsequently chlorosis follows along the tertiary veins, again starting with those nearest the base of the leaf segments. The affected area, at this stage, has a somewhat serrated outline. If the chlorosis proceeds further the sharp outlines between affected and normal green tissue become diffuse and the chlorotic areas coalesce forming blotchy patches, sometimes involving a considerable proportion of the lamina. The colour of affected areas is usually a pale shade of yellow.

In the second type of leaf symptom, which is of more common occurrence than the first, the chlorosis may best be described as a mottle (Plate 1, Fig. 2, and Plate 2, Fig. 3). In very mild cases the mottling is faint and more or less evenly distributed over the whole leaf surface but, unlike the first type, there is no definite association with the secondary veins (Plate 1, Fig. 2). With increasing severity a larger proportion of the lamina becomes chlorotic and in extreme cases the whole leaf is blotchy (Plate 2, Fig. 3). The intensity of yellowing varies considerably in different clones.

The lower leaves of severely affected plants present a striking appearance in contrast to the fully green younger leaves and such plants can be detected some distance away. Diseased leaves may remain attached to the plant for several weeks, particularly in periods of active growth, but if drought sets in or the cool season intervenes the lower leaves are shed progressively and a diseased plant may appear to be quite healthy, unless there are obvious stem symptoms.

In the hot season (December to March), leaf symptoms, as a general rule, do not develop in new growth, except in highly intolerant varieties. A field examined during this period may appear to be free from the disease, but when temperatures fall the same field may prove to be fully infected. On the other hand, leaf chlorosis, once it has appeared, persists in affected leaves, no matter what climatic changes take place.

Stem Symptoms.—As with leaf symptoms, stem symptoms are by no means a regular feature of the disease except in clones with low tolerance. In such clones symptoms generally occur in three well defined stages. The first (Plate 3, Fig. 5) is the appearance on the young green portion of the stem of small, narrow, isolated streaks a few millimetres or more in length; these lesions are situated in the cortical tissue and have a black or brown colour as seen through the epidermis. As the disease progresses these lesions elongate and coalesce with adjacent streaks forming blotchy patches which, however, may not be obvious once bark has formed, although they do persist and can still be detected in pale stemmed varieties.

In diagnosing brown streak in the young green stem another condition which simulates brown streak and might be wrongly diagnosed as such is often encountered in particular clones. This condition is depicted in Plate 3, Fig. 6. It consists of numerous dark-brown circular spots distributed irregularly over the surface of the green portion of the stem. Initially these spots are minute but they increase in size and finally attain a diameter of roughly half a centimetre. The increase in size of these spots is accompanied by the appearance of a series of concentric rings; the centre of the spots being darker than the peripheral region. The colour of the spots becomes progressively paler with age, and when bark formation is complete they are no longer visible. Spots of a similar type are sometimes seen on the old leaves of affected plants. Usually the spots do not appear until the cool season has set in. If cuttings are taken from affected plants and propagated in the hot season the new growth is quite normal and it is only when the temperature falls that the spots reappear.

The cause of this condition is unknown but it is not considered that a virus is concerned since it is of regular occurrence in certain clones and is not transmissible to others by grafting. The essential difference in distinguishing between brown streak and the spotting described above is that in the former the browning penetrates deeply into the cortex whereas in the latter the spots are confined to superficial tissue. This is easily demonstrated by gentle scraping with a knife.

The second stage in the development of brown streak stem symptoms is the formation of necrotic lesions in the leaf-scars remaining after the leaves have been normally shed. By paring away thin layers of tissue from the exposed abscission layer these will be revealed, a few millimetres below the surface. Typically these lesions are sepia in colour but in some clones they tend to be black; they are not confined to any particular tissue and may appear in any position (Plate 3, Fig. 7). Sometimes the necrosis extends into the proximal end of the petiole of a leaf still attached, but seldom for a distance greater than a centimetre; rarely, similar necrotic areas are found at the distal end of the petiole but the necrosis has never been observed to traverse its entire length.

In mild infections the external appearance of the mature stems is usually quite normal and on examination the majority of leaf-scars very often show no signs of infection, but the presence of a single lesion is sufficient to make a positive diagnosis. In more severe infections a high proportion of leaf-scars show the characteristic sepia lesions, one or more in each scar. The lesions increase in size, finally investing the dormant buds and killing them. Once formed these leaf-scar lesions persist; they therefore provide the best and most reliable, single, diagnostic symptom of the disease.

The third and final stage in stem infection consequent on further degeneration of stem tissues is found only in highly intolerant varieties which are liable to be killed by the disease. The early "green stem" symptoms may or may not have shown in the initial stages; leaf-scar symptoms are always present, a large proportion of the nodes being affected, together with the inter-nodal cortical tissue. Most, if not all the leaves are shed. Once the axillary bud has been killed a general shrinkage of the node takes place accompanied by shrinkage and death of the inter-nodal tissues (Plate 3, Fig. 8). Death takes place from the tips of branches and proceeds downwards so that the general effect is one of die-back (not to be confused with physiological die-back described below). Cold weather hastens the break-down process and the final picture is one of bare, dead stems which are very brittle, light in weight and break off readily.

A tendency to recovery is by no means uncommon in some clones. One or more buds may survive on otherwise moribund stumps and with the advent of warmer weather these buds may develop into shoots. The degree of regeneration depends on the tolerance of individual clones.

A physiological die-back induced by cold weather is of common and regular occurrence in particular clones. The effects are more pronounced at higher altitudes where cool season temperatures are relatively low, but even on the coastal plains highly susceptible clones suffer to some extent. The onset of die-back is usually quite sudden; one week a plant may be in full leaf and normal in appearance and the next the tips of the branches are bare and dead. Young plants or plants in active growth are not affected, which implies that a plant must have reached maturity or growth have been temporarily suspended, due to drought or a fall in temperature, before signs appear. If the plant is intolerant of this lowering of temperature it reacts by dying-back from the tips of its branches; meanwhile the lower leaves may still be attached but eventually all the leaves are shed. Clones more tolerant of cold simply shed some or all their leaves but the branches do not die. It is only the thin tips which die and death is automatically checked lower down where the branches attain a thickness of something over half-an-inch in diameter; therefore it is rarely that more than about eighteen inches of the upper branches is affected, whereas in the die-back caused by brown streak the mature stems are also affected. When warmer weather sets in the buds immediately below the dead tips of plants affected by physiological die-back develop, with the result that a whole cluster of young leafy shoots is produced with the dead tips of the old branches standing out above them. After a time the plant shows no signs of having died back.

Fruit Symptoms.—Symptoms on the fruit are generally found only in clones which show symptoms in other organs of the plant. Plate 2, Fig. 4, illustrates the appearance of affected unripe fruits which bear numerous black spots of varying size distributed unevenly over the green pericarp. The necrosis is not superficial but extends into the fleshy tissues below.

Root Symptoms.—Root symptoms are also variable; they may be external, internal or both. External symptoms show as longitudinal fissures up to a centimetre or more in length on the surface of the root cortex and of a depth not exceeding its thickness. The roots may be normal in shape (Plate 4, Fig. 9), or misshapen (Plate 4, Fig. 10); in the latter case the fissures are more numerous in the region of the radial constrictions. The tissue surrounding the fissures is always discoloured, either black or sepia. In other cases roots may be quite smooth and normal in appearance and it is only by paring the cortex that necrotic lesions are revealed within it. Fissure formation is probably a later development from these hidden lesions.

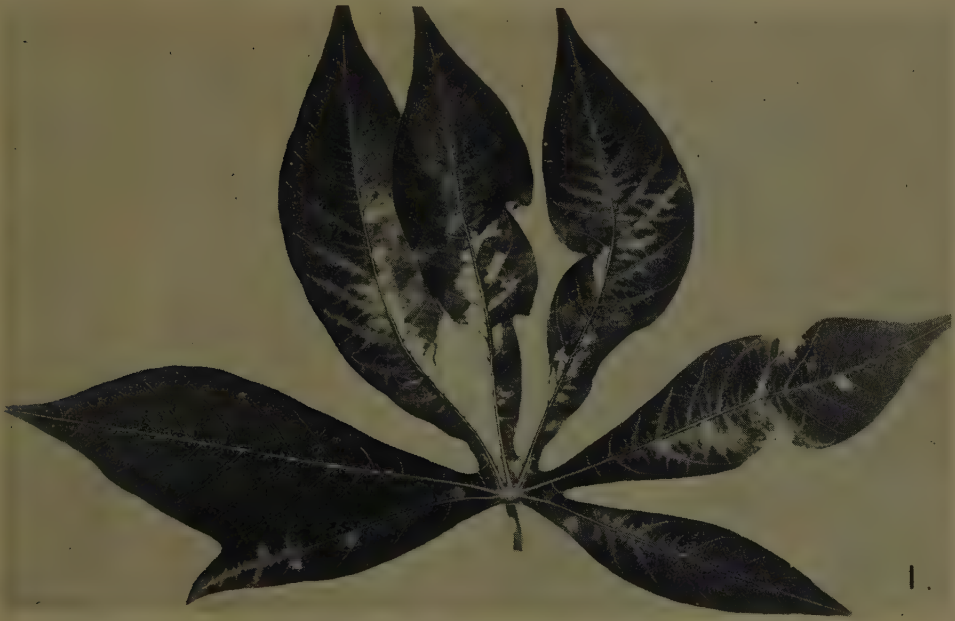
The internal type of root infection manifests itself by the formation of lesions in the tuberous starch tissues, the frequency of these lesions depending on the tolerance of individual clones. Plate 4, Fig. 11, shows root sections of two varieties, one of which is only mildly affected and the other highly intolerant. There may or may not be fissures or lesions in the cortex of roots which are affected internally. Internal lesions vary in colour; they may appear as yellow semi-translucent blotches or streaks, or as sepia or greenish-black necrotic lesions, the sepia type being more common. Yellow and sepia or greenish-black lesions are sometimes found in the same root. It ~~is~~ possible that the yellow type is the initial colour change which subsequently develops into one of the other two colours.

In mild cases a prolonged inspection of all the roots of a diseased plant may reveal only an occasional fleck so that it is quite easy to miss an infection. In highly intolerant varieties the whole of the starch storage tissues may be involved; in such cases the roots are quite useless. There is no decay in the ordinary sense of the word and it is only after secondary organisms gain an entry that putrefaction takes place.

DISCUSSION

The salient fact concerning the known geographical distribution of the disease is that it is confined to relatively low altitudes where minimum temperatures are comparatively high. That lower temperatures and the absence of secondary spread are the controlling factors at higher altitudes is amply borne out by field observations.

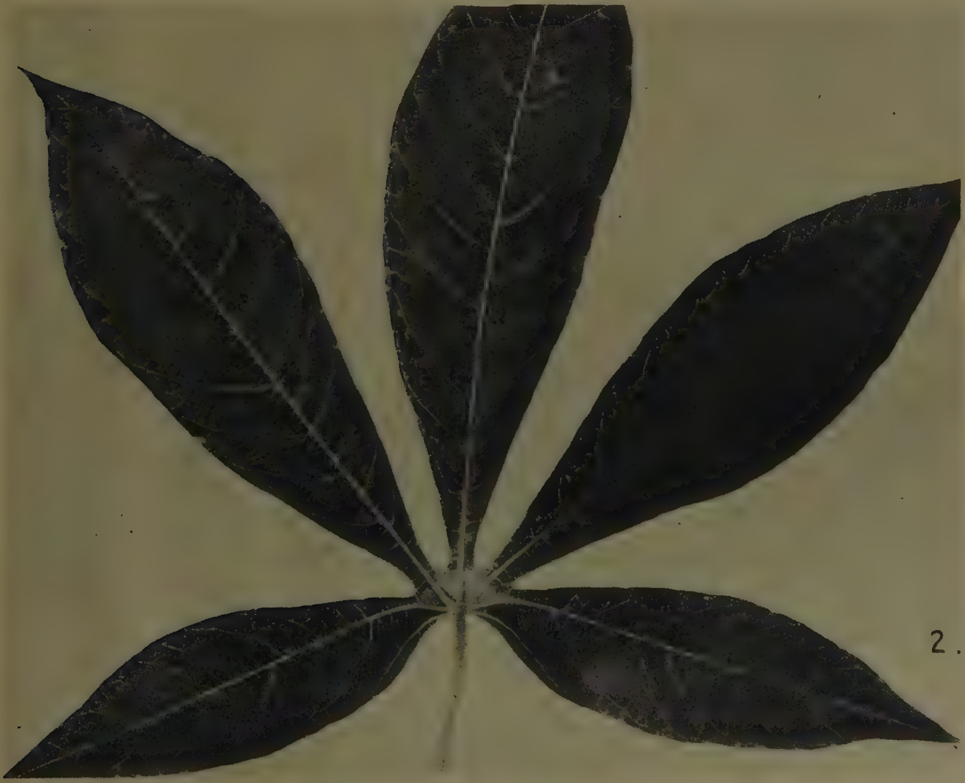
These observations have practical significance; they mean, in fact, that clones susceptible to brown streak can be grown above pre-determined altitudes without fear of their contracting the disease. Were it not for the incidence of mosaic, which is still a problem at these altitudes, such a policy could be adopted forthwith. The stumbling block, at present, is the production of satisfactory mosaic-resistant clones.



1.

FIG. 1—One type of brown streak leaf-chlorosis which traces out a pattern along the secondary and tertiary veins. (This leaf also shows localized mosaic infection.)

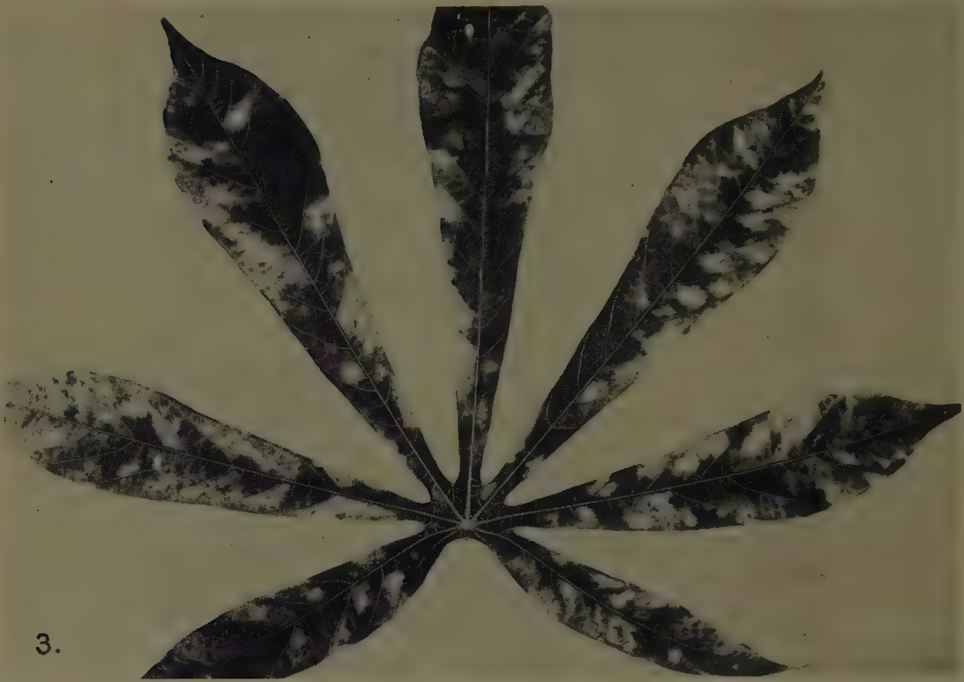
Variety "Mkamba". × ½



2.

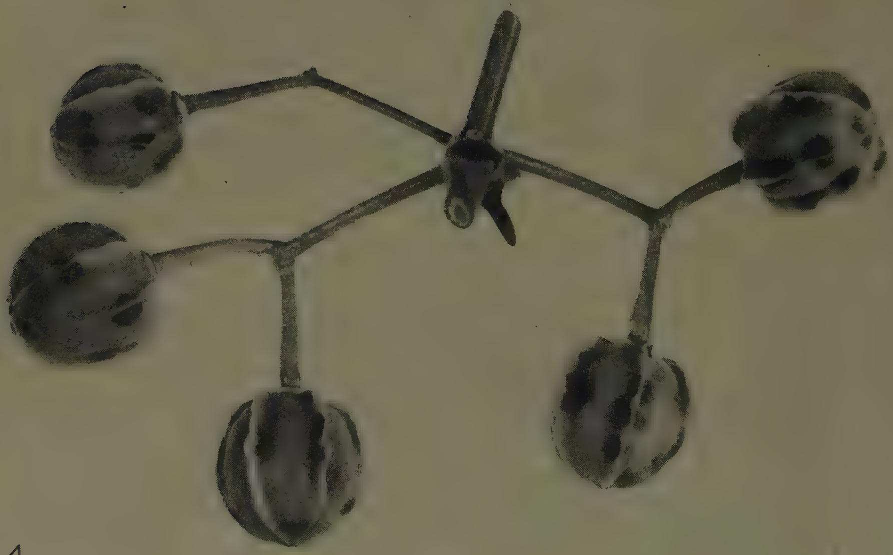
FIG. 2—Mild form of the second type of brown streak leaf-chlorosis. The evenly distributed faint mottling bears no definite relation to the secondary veins.

Variety "N 3". × 1



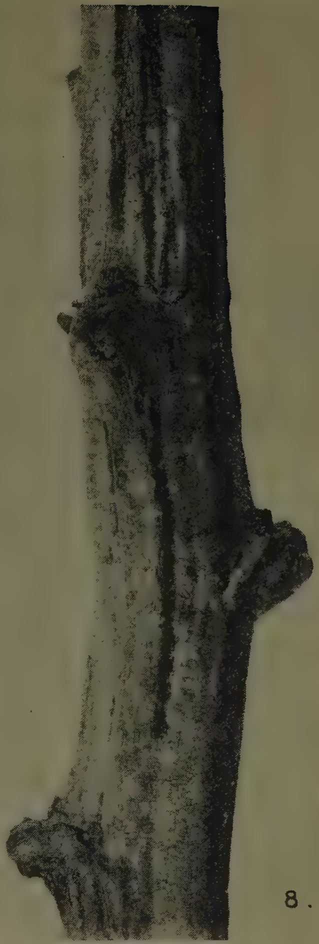
3.

FIG. 3—Severe form of the second type of leaf-chlorosis. Here the mottling is far more intense and a greater proportion of the lamina is affected.
Variety "Katoto". × ½



4.

FIG. 4—Unripe green fruits of cassava showing circular, black, necrotic lesions, caused by brown streak infection, distributed over the pericarp.
Variety "Mkezumbe". × 1



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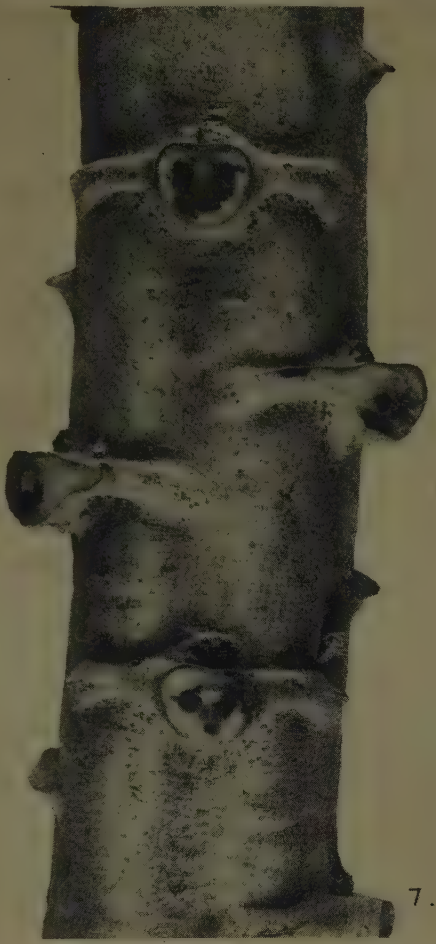

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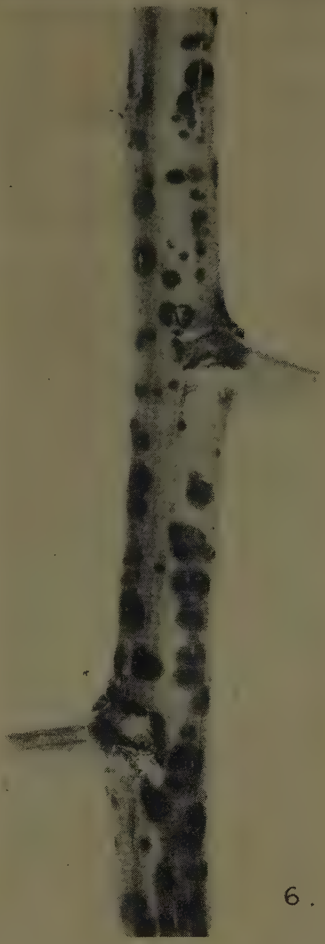

6.

5.

FIG. 5—Streaky lesions in the cortical tissue as seen through the epidermis on a young green portion of stem before bark formation.
Name of variety not known. × 1

FIG. 6—Superficial circular spots, the cause of which is not known, on a portion of young green stem. Shape and superficial nature of these spots distinguish them from brown streak lesions shown in Fig. 5.
Specimen from a back-crossed inter-specific hybrid. × 1

FIG. 7—The sepia-coloured necrotic lesions revealed by paring away a thin layer of tissue from the surface of the leaf-scars on an infected mature stem. Note that the external appearance of the stem is normal.
Variety "M 5". × 1

FIG. 8—External appearance of mature stem showing general shrinkage of leaf-scars and internodal tissues in advanced stage of stem infection, following death of axillary buds.
Variety "Malindi". × 1

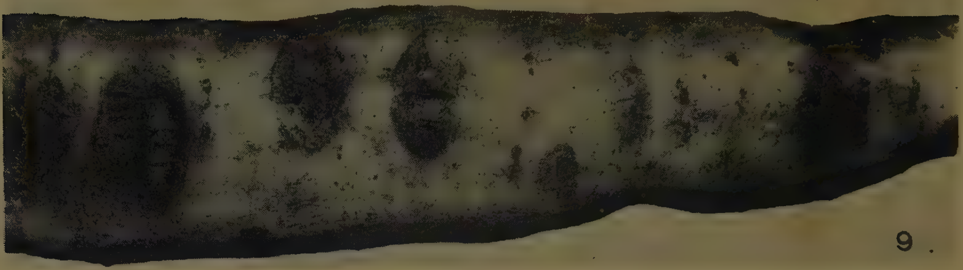

FIG. 9—Longitudinal external fissures in the root cortex of a root otherwise normal in appearance.
Variety "Mpera". × ½

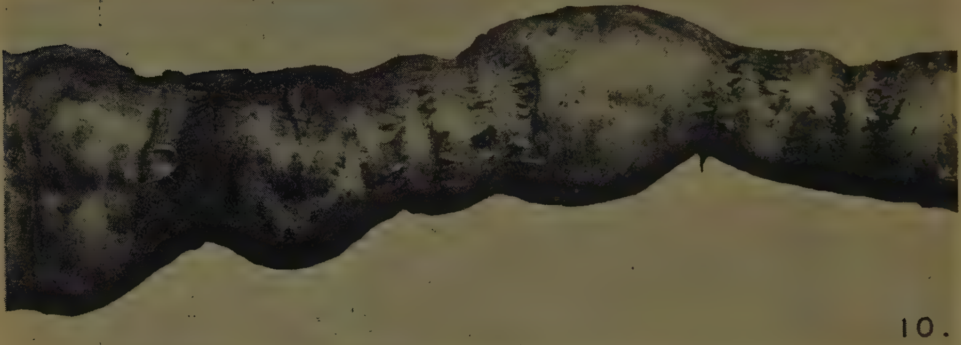

FIG. 10—A mis-shapen root showing the longitudinal fissures confined to the radial constrictions of the root.
Variety No. 37206 F. × ½

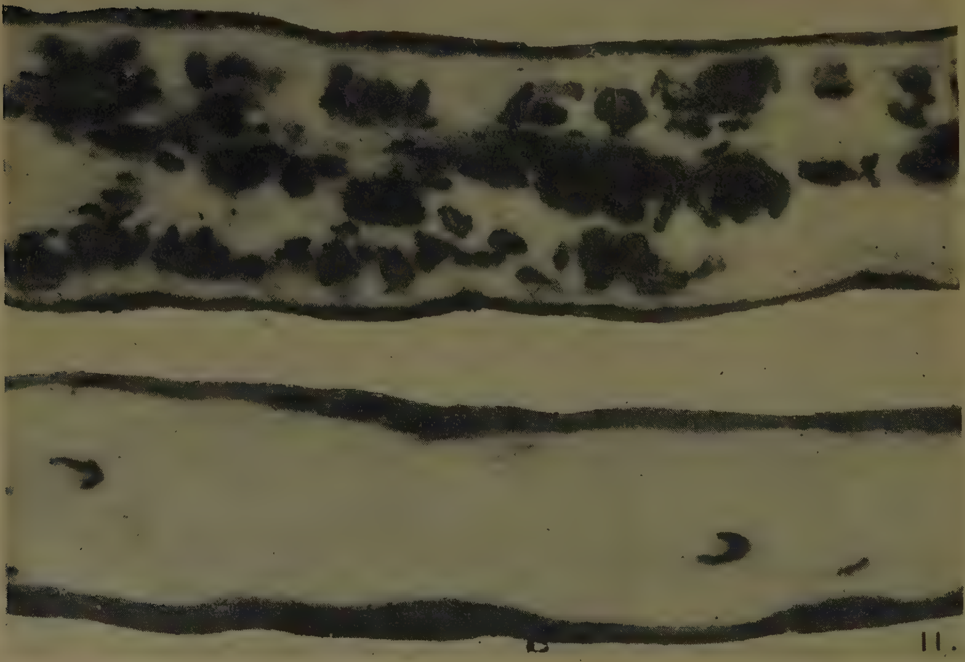

FIG. 11—Two roots of different varieties split open longitudinally to show the necrotic lesions in the starch storage tissues. Variety "Mbarika" is only mildly affected whereas in Variety No. 4026/15 infection is severe. × 1

Another striking feature about brown streak is that a "natural control" operates at low altitudes; this may account for the disease having escaped detection until recent years. Even at low altitudes highly intolerant varieties succumb in the cool season, or if they do survive their roots are so badly affected that cultivators discard them; the net result is that varieties which are possibly immune or only mildly affected have been perpetuated in these areas. This is undoubtedly brought about by the large number of "volunteer" seedlings which appear annually in native cultivation; such seedlings are harvested in due course; any that yield well and are satisfactory in other respects are propagated from cuttings, otherwise they are discarded. When a new clone is outstandingly good it soon supersedes the "standard" variety of that particular district. This process is going on continuously hence the multiplicity of varieties to be found throughout the country.

During the course of the cassava breeding which has been in progress at Amani for some years it has become abundantly clear that the wide variation in susceptibility to brown streak is a varietical characteristic and therefore presumably controlled by genetical factors. It is relatively easy to breed highly tolerant varieties or varieties possibly immume from natural infection, but no such cassava has yet been produced with sufficient mosaic resistance and yielding capacity to warrant it being considered better than anything in cultivation in areas where both virus diseases are limiting factors. A high degree of mosaic resistance coupled with resistance to brown streak has been attained in some clones but in every case the yielding capacity has been low. The answer to the problem is being sought in inter-specific hybridization. The results, to date, are very promising.

The range of symptoms, which is unusually large for a virus disease, may lead to the supposition that detection of the disease is easy. Except in cases of high intolerance this is not always so for the reasons stated in the text.

Leaf symptoms, although they are characteristic, do not develop, as a rule, in the hot weather; they are seen best in mature or nearly mature plants in the cool season; but this is the time of greatest leaf-fall and the lower leaves showing symptoms may have been shed at the time of inspection. And finally a particular clone may never show leaf symptoms. The absence of leaf symptoms, therefore, is no guarantee that a particular plant is healthy.

Symptoms in the young green stem are by no means of universal occurrence in susceptible clones and failure to detect them is no proof of freedom from the disease. Diagnosis is easy in advanced stages of stem infection but in mild cases it may be necessary to examine the leaf-scars at most of the nodes of a plant before finding a single lesion.

Root symptoms have been described as they are seen at harvest time. The stage of growth at which root symptoms appear in primarily diseased plants is not known nor is it known how soon after infection they appear in the roots of plants which become infected in the field. There may be one or more transitional colour changes in the development of lesions in the roots such as that suggested by the appearance of both yellow and sepia or black lesions in a single root.

When roots are badly affected it is probable that one or more of the above-ground symptoms will have been detected, but this is not invariably the case. If there are few root-lesions, above-ground symptoms may be totally absent. To be quite certain that a plant is entirely free from the disease calls for a very thorough examination of the above-ground organs as well as the roots.

To reiterate, a particular clone may show leaf symptoms only, stem symptoms only, root symptoms only or a combination of two or more types of symptom. The consistent presence or absence of any particular symptom in any one infected clone is attributable to genetical factors.

Most African cultivators, in endemic areas, are familiar with brown streak root symptoms in the severe form; when asked to account for them the invariable answer is that the roots have been in the ground too long, or that there is too much water in the soil. It is well known that conditions approaching water-logging of the soil very soon lead to decay of cassava roots.

SUMMARY

So far as is known the distribution of the brown streak virus disease of cassava in East Africa and some adjacent territories is limited to the coastal plains and certain areas inland not exceeding an altitude of about 3,500 feet

above sea-level. This figure may have to be modified in the light of future knowledge.

The absence of the disease at higher altitudes is not fully understood. Severely diseased plants are known to die at these altitudes during the cool season but no satisfactory answer has yet been found to explain the absence of secondary spread, by the insect vector, in these regions.

High temperatures tend to inhibit development of disease symptoms which normally only make their appearance in infected plants when seasonal temperatures begin to fall. The effects of the disease are more pronounced during cold weather which results in a measure of partial control through the elimination from cultivation of highly intolerant clones; this is brought about either through death of severely affected plants or more commonly through deliberate selection by cultivators.

Susceptibility to the disease ranges from what appears to be complete field immunity in some clones, through a series showing varying degrees of resistance and tolerance, to clones which are so severely affected that they are killed when seasonal temperatures are low. These variations in susceptibility and tolerance are attributed to genetical factors.

Symptoms are recognized in leaves, stems, fruits and roots of the plant and they may occur in only one of these organs or in two or more depending on the susceptibility of individual clones. The presence or absence of symptoms in these organs is constant for any given clone.

Mosaic disease is of universal occurrence in all brown streak areas, therefore the breeding of clones immune or highly resistant to brown streak alone is of little use in these areas. High resistance to both diseases has been attained in some cassava clones but yielding capacity is low in them. Control of both virus diseases is being sought by inter-specific hybridization.

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A NOTE ON THE KENYA FORESTRY POLICY

During the 1914-1918 war, the vital part that timber plays in peace as well as in war was brought home to the British Government. It was decided to hold a conference of foresters from all parts of the Empire to discuss this and other matters of common interest. Subsequently, similar conferences were held at intervals of five years until the Second World War interrupted the sequence, and incidentally played havoc with the plans made for increasing the available supplies of home-grown timber in Britain.

The fifth conference of the series was to have been held in India in 1940. In the event, it took place in Britain in 1947.*

Data contributed by delegates at this meeting show that, within the Empire, Canada and Newfoundland alone have an exportable surplus of softwoods—for those who have the dollars with which to buy. It may be worth mentioning here that in 1938 Britain imported some £63,000,000 worth of timber and that about 96 per cent of the money was spent on softwoods.

We in Kenya are directly concerned with the progress of forestry in many other parts of the Empire. The reason for this is that Kenya is one of the very few Empire countries capable of producing an exportable surplus of softwoods at an economic price. It is true that the total area of land which could, and should, be devoted to the growing of fast-growing softwoods in the Colony is very small, compared with the vast coniferous forests of the Northern Hemisphere. Yet climatic conditions here enable us to reap crops of good, millable logs in from 30 to 40 years, while similar logs grown in Scandinavia or in Canada might need from 80 to 200 years or more. In effect, this means that every acre of land under fast-growing softwoods in Kenya is producing annually the equivalent of the yield from three to six or more acres in Northern latitudes. Under these conditions the land available for forestry purposes in Kenya—land which in any event must be kept under a forest crop of sorts for the vital matter of water and soil conservation

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* Fifth British Empire Forestry Conference, Great Britain, 1947, Summary Report. Published by H.M. Stationery Office, 56 pages, price 1s.

—can be made to yield a great deal more timber than will be consumed locally, even after making generous allowances for the future needs of the African populations of this and adjacent territories.

Many readers of this journal are probably unaware of the very considerable developments that have taken place in connexion with forestry in the Colony during the past decade, but the following figures are revealing:—

Year	Total strength of F.D. staff excluding labour	Output		Gross revenue	Gross expenditure
		Timber in Hoppus tons	Firewood in millions of stacked c.ft.		
				£	£
1939	51	23,645	11·5	43,702	31,040
1941	97	45,251	15·2	75,135	29,478
1943	132	83,588	23·0	140,500	45,712
1945	161	116,536	27·2	156,314	74,364
1947	436	80,307	19·7	122,024	119,519
1948	430	104,837	22·0	152,862	142,050

Much of the firewood came from plantations of eucalyptus made for the purpose, but the bulk of the mill timber was cut in the indigenous forests. At present, the Department is planting about 6,000 acres of exotic softwoods per annum. As these trees mature, in from 35 to 40 years, it is estimated that their annual yield will exceed 1,000,000 Hoppus tons; but long before this very large quantities of timber will become available from thinnings.

It is probable that the rate of planting could be doubled without undue difficulty as more trained staff becomes available, and in view of the rather precarious position as regards future softwood supplies in many other parts of the Empire it might be advantageous for the Home Government itself to press for this to be done.

At the 1935 Empire Forestry Conference, held in South Africa, the following resolution was passed:—

> "In view of the great importance to the Empire as a whole, as well as to each of its component parts, of producing a sustained yield of all classes of timber, of encouraging the most economical utilization of timber and other forest products, and of maintaining and improving climatic conditions in the interests of agriculture and water supply, each of the Governments of the Empire should lay down a definite forest policy to be administered by a properly constituted and adequate forest service."

The 1947 meeting reaffirmed this resolution.

Kenya's policy, as set forth in the Development Committee's Report of 1946, reads as follows:—

"The Ultimate Object of Forest Policy in Kenya

Forests a National Asset.—Forests are a national asset and must be maintained, both for the improvement of the country itself, and for the benefit of the people who live, and will live in it. World-wide experience has shown that, with a few exceptions and for a variety of reasons privately owned forests are eventually destroyed, and that it is, therefore, the duty of the Government, in order to protect the people from their own improvidence, not only to retain under its own management a high proportion of the forests of the Colony, but to frame for that forest estate a long-range policy, based on its particular requirements, unaffected by political or other changes, and backed by stable finance. Only by taking action on these lines can Government fulfil its obligations, in respect of its forests, to posterity.

Reservation of Forests.—Forest reservation must be continued until it covers not only all forests useful, or likely to be useful, for the timber they contain, or can be made to produce, but all forests, or potential forests, the protection of which is desirable for climatic reasons.

Forest Management.—At the earliest possible moment all forests must be brought under proper scientific management. This will be achieved by the preparation for each district of a detailed working plan, in which will be set forth prescriptions and programmes covering all protection, utilization, reafforestation and development measures considered necessary. Continuity of action, strict adherence to Government policy and due regard to economy will be ensured in these plans, by their covering a ten-year period before revision and by their being sanctioned by Government before being brought into force.

Protection Forests.—It is essential that protection forests should be maintained and established wherever necessary in order that their climatic benefits may be fully effective.

Forestry Outside Forest Areas.—All means must be taken to encourage forestry and the planting and care of trees throughout the Colony, whether on farms, in native areas or elsewhere.

Forest Production.—All forests must be brought to such a state of production as to ensure that a sufficient supply of timber and other forest products is available on a sustained yield basis to satisfy (*a*) the demands of the local population and industries, and (*b*) estimated export requirements.

Employment in Forests and Allied Industries.—Although clearly not one of the objectives of forestry, it must be realized that a progressive forest policy must result in the employment of a very largely increased number of persons in the forests and in allied industries."

Various other resolutions, dealing with policy, were passed at the 1947 Conference. They stressed the importance, in particular, of (*a*) Continuity of Policy. When dealing with crops which take 30 years or more to mature, this is an obvious necessity. It would be most uneconomical, for example, to plant 100 acres of pines per annum in a block for five years, and then to abandon the scheme. To do so would mean that, in due course, there would be only 500 acres of timber ready for exploitation. It would not be worth while for any miller to spend money on erecting a good modern sawmill to deal with this amount of material; whereas if planting were to be continued at the rate of 100 acres per annum for 20 or 30 years in one block, then a miller would know that he would have 20 or 30 years cutting in view in that area, and he could afford to lay out the necessary capital. (*b*) The provision by the Government concerned of sufficient funds to enable Forest Authorities to carry out accepted policies. (*c*) The reservation, for the purpose of economic management, of all land which should, under sound land planning, be retained under or put under a forest crop. (*d*) Legislation to prevent the alienation of forest land excepting for reasons consistent with the maintenance of the forest policy as a whole.

In these matters, Kenya is not too badly off excepting for the fact that, under sound land planning, many more protection and production forests should be made in certain native land units. The Kikuyu in particular should be made to understand that any further excisions from existing forest reserves would be detrimental rather than beneficial to them.

As regards a resolution passed on the question of a survey of resources, the position is not so good. Detailed stockmaps, showing what timber there is in the country, are almost completely lacking excepting for plantation areas, so that it is impossible to say how much timber may safely be cut per annum until our plantations come into bearing. However, a considerable amount of aerial photography has recently been done in the Colony, and a specially trained officer is now engaged in the interpretation of these photographs. Within a year or two much information will have been transferred to the maps. In the meantime there is still an acute shortage of surveyors to carry out very necessary ground surveys to supplement the photographs.

Similarly, with regard to all branches of research, the position at the moment is undoubtedly most unsatisfactory, but the indications are that matters will improve rapidly in the near future. A plant pathologist, loaned to the department from the East African Agriculture and Forestry Research Organization, is now working on cypress canker and other fungal diseases of trees. A silvicultural research officer is expected shortly. A post exists for a soil chemist when a suitable candidate can be found to fill it, and another officer is working on utilization and marketing problems.

The basis of all sound forestry is the working plan. Rudimentary plans for the management of plantations have been in existence in some districts for the past 20 years, but they were drawn up by divisional officers in their spare time only, and covered a very small fraction of the total area of forest reserves. A separate Working Plan Branch has now been established and a very great deal of work has already been done in this vital matter.

On the whole it may be said that the prospects for forestry in Kenya, and hence the prospects for Kenya itself, are brighter than they have ever been.

R. M. GRAHAM.

BOOK REVIEW

"THE CLOVE TREE" by G. E. Tidbury, B.Sc., A.R.C.S., A.I.C.T.A.—*Crosby Lockwood and Son, London,* 1949, *price Sh.* 18.

Dr. Johnson wrote "No one can write the life of a man but one who has ate and drunk and lived in social intercourse with him". In so far as these conditions can hold between a man and a tree, no one is better qualified than Mr. Tidbury to write on the Clove: and he has made good use of his opportunities. Although cloves have been in use for more than two thousand years and an important article of commerce for five hundred, no one has yet written a book about the crop. This deficiency has now been adequately dealt with in twelve chapters, covering two hundred pages. A comprehensive account is given of the history of the industry, the soils, topography and climate of Zanzibar, agronomy, picking and preparation, disease, costs, valuation, and the uses to which the crop is put. Incidentally, one wonders how many people outside the trade know that one of the main uses of the clove is to flavour cigarettes for Indonesian consumption!

One of Mr. Tidbury's main sources is, as might be expected, the records of the Zanzibar Department of Agriculture which has been carrying out work on the Clove for decades. In one sense, therefore, some of the information has been published before, in that data have appeared in annual reports. But this does not, to my mind, constitute publication proper, which should necessitate the appearance of collated data in a form easily available to all.

It would be a good thing if more departmental officers in all Territories would follow Mr. Tidbury's example and rescue from oblivion some of the valuable results concealed from the general reader in departmental reports.

To have produced a standard text (which the book will eventually become) is a subject for congratulation. To have made it, in the main, interesting reading as well, is something of a feat. One rarely chuckles over a textbook; but I did when reading this one. I particularly like the list of reasons for Arab indebtedness, ending with "unremunerative activities of a social nature". It is, to my mind, a pity that a writer capable of such flashes of verbal felicity should consistently refer to himself as "the present writer". The present reviewer agrees with the past writer of an editorial in the present Journal (Vol. V, 1939, p. 6) and pleads for the avoidance of such circumlocutions.

In the first chapter the clove industry is traced from the Moluccas across the Indian Ocean to Zanzibar where it has long been the main crop. Indeed "there is probably no country in the world where one crop assumes such paramount importance, where such a large proportion of the income of both government and people derives from a single source, and where so large a section of the population is personally affected by changes in the handling of one article of commerce". The establishment of the industry in Zanzibar seems to have been largely fortuitous and due to the acquisitive habits of an Arab malefactor combined with despotic action on the part of Sultan Said bin Sultan who ordered the planting of the crop in the islands.

The resurgence of the industry after its near-destruction in 1872 by a hurricane was the result of similar action by Sultan Bargash bin Said. Thus, strong action started the industry; strong action saved it in 1872; strong action may be necessary in the future to save it from the threat of disease.

In one respect Mr. Tidbury has been unlucky: his foreword is dated January, 1947. The book was not published until late 1949. There have been considerable advances in our knowledge during this period and certain chapters already need amplification or revision. I hope that opportunity will be afforded for the early preparation of a second edition.

The chapter on costs is a good example—and guaranteed to produce an attack of acute nostalgia. Most of us realize, in a rather vague way, that times are not what they were and that wages and costs have risen; but Chapter Nine emphasizes the enormous changes that have taken place. For example, the pre-war daily wage for a labourer was Sh. 0.65; after the war it was Sh. 1 or Sh. 1.30; the legal minimum wage in 1949 is Sh. 2. A wage increase of over 300 per cent in a decade is remarkable.

The sudden-death disease naturally dominates the account of diseases and pests. This interesting disease occurs in both Zanzibar and Pemba and is also found in Madagascar.

It has no specific premonitory symptoms, although experienced observers can often detect it some time before the onset of the spectacularly sudden final symptoms—heavy leaf-fall followed by strong wilt. It has been known in Zanzibar for half-a-century; and although it has been studied at intervals since the 1920's, no definite cause has yet been found. Various theories of its causation are reviewed with careful impartiality, but no hint of Mr. Tidbury's personal views is given —an omission which I regret.

For some time past it has been current practice in Zanzibar and Pemba to underplant diseased plantations. This may give good results from an arboricultural point of view; but although the sudden-death disease was popularly supposed, in 1946, to be non-pathogenic, a pathogen always remained a possibility. Where there is even a suspicion that death is due to a pathogen, the planting of seedlings among dying trees is unsound by all generally accepted standards.

This criticism apart—and it must be remembered that the views expressed were those of the time—the book is one thoroughly to be recommended. It is commendably free from printers' errors (I found none); and from errors of fact (but *Oecophylla smaragdina* on page 153 should be *Oecophylla longinoda*). It is well printed on good quality paper, while the twenty-five illustrations, mostly from the camera of Mr. Fergus Wilson, M.B.E., are excellent and add no little to the interest of the book.

F.J.N.

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Kenya, Tanganika
Uganda and Zanz

BRAZILIAN METHODS OF PREPARING CASSAVA

Cassava, originating in Tropical South America as a food crop, was probably introduced into Africa by the Portuguese. Whether or not they brought the "sweet" or "bitter" variety in the first instance is uncertain, but it appears that the traditional way for preparing this potentially dangerous crop for food never crossed the Atlantic. Livingstone, visiting Angola in 1854, detailed the preparation of "farina" as in Brazil, but notes that the sweet variety only was grown. For obvious reasons the more robust, higher yielding "bitter" cassava gained popularity but as it spread across the continent, the art of preparing "farina", if ever known, was lost, and an insight into the disasters which attended the use of this food in Africa by the uninitiated can be gained from the story of Stanley's journey up the Congo during the year 1887.

Cassava as prepared by the African is, to European taste, a nauseating product and so, in these days of food-consciousness, it seems worthwhile recording the preparation of the crop as practised in South America. The roots are dug, scraped with a knife and washed. They are then grated. The grater used by South American Indians consists of a board upon which a great number of little "flints" are imbedded in a coating of wax but, of course, simple machinery or even a perforated 4-gallon kerosene tin can be made to perform this part of the process. The damp pulp is next squeezed. The traditional instrument for this purpose is a basket-work cylinder which is specially woven so that it can be packed short and fat. At one end there is a loop which can be fixed to a convenient hook and the "sock" is then pulled until it is long and thin. This performance exerts great pressure and all the poisonous juice is in this way extracted from the pulp. Any simple press has the same effect.

Two products have now been obtained, viz. the squeezed pulp and poisonous juice. From the pulp two more products are prepared—"farina" and cassava bread. The former is much favoured by the Brazilians and I give the process for its preparation: Before the pulp is too dry, a little pulp that has already been fermented for three days is added to the mass to give "quality". After mixing together, the whole is then pounded and rubbed through a sieve to produce a slightly damp meal. Meanwhile a fire has been built under a large iron pan which is greased with a little fat. The meal is then thrown on to the pan and "scalded" until dry.

The product thus produced is granular and being only slightly toasted, is a pale yellowish colour. If dry it will keep indefinitely. "Farina" is eaten like rice with meat and gravy—it is indeed excellent as a cereal. Travellers find it a very sustaining quick meal and a little double-ended bag is usually carried across one's saddle, in one end of which "farina" is placed and in the other, sugar. When a stream is crossed, a cup is filled with water and into this is thrown a handful of the "farina", sugar being added to taste—the liquid is agitated and then becomes a pleasant beverage.

The aborigines, however, favour cassava bread and the process is as follows: The squeezed pulp is dried and thrown on to an iron pan over the fire and spread out into a circle like a large pancake. The whole is baked until slightly brown on one side whereupon the meal sets into a solid slab without any addition of water. The cakes are then further dried in the sun and in this state they will keep indefinitely. Cassava bread, unless very thin, is iron-hard, nevertheless it has an excellent flavour and is usually eaten after being dipped in gravy.

To return now to the poisonous juice—this is allowed to stand in a trough and white starch precipitates, leaving all the poison in the supernatant liquid which is poured off. However, even the liquid is not always discarded, because from this can be prepared the well-known West Indian hot sauce known as "Cassareep". The white starch is essentially the "tapioca" of commerce and in Brazil it is very largely used for making delicious little cakes.

It is evident, therefore, that the roots fermenting and stinking in African wayside pools by no means represent an essential process in rendering cassava innocuous but that, on the contrary, several palatable foods can be prepared from this crop.

D. VESEY-FITZGERALD.

REVIEW

Propagation of Trees, Shrubs and Conifers.—*By Wilfrid G. Sheat, Macmillan and Co., Ltd., St. Martin's Street, London, price Sh.* 25, *pp.* XII + 479 (1948).

For those who are interested in the propagation of plants Messrs. Macmillan have published for the price of Sh. 25 a 455-page book by Wilfrid G. Sheat entitled Propagation of Trees, Shrubs and Conifers. Mr. Sheat is Horticulturist to the Ministry of Transport and was formerly attached to the Royal Botanic Gardens, Kew. He first acquired a knowledge of propagation in nurseries in New Zealand followed by experience gained in commercial establishments in the British Isles.

The book contains a preface, followed by a foreword by W. Dallimore, an authortiy on trees and shrubs, and at one time member of the staff of the Royal Botanic Gardens. In his introduction the author says his book "Is an attempt to provide a systematic and reliable source of information covering a varied selection of the most successful methods of propagation usually employed in commercial nursery establishments". He points out that the various methods of propagation he suggests and describes in detail are by no means the only ones but are methods which appeal to him as being most applicable to commercial production. "The essential factor governing the use of one method or another is economy of production—compatible with the subsequent growth and general well-being of the plant".

The main body of the work is divided into two parts, Part I, Angiosperms, pp. 1–403, Part II, Gymnosperms, pp. 405–448. The section under Angiosperms opens with methods of propagation by seeds; open ground sowing; under-glass sowing; by division; by layering; by French-mound layering; by cuttings in open ground; in cold frame, in sun frame, under bell-jars; under glass (close case); eye cuttings; and root cuttings under glass and in the open ground; by grafting under glass and in open ground; inarching; root grafting under glass, and by building. Then follows the genera that are dealt with arranged alphabetically commencing with *Abelia* in the Caprifoliaceæ ending with *Zenobia* of the *Ericaceæ*.

To take an example "*Acacia* (Mimosa, Wattle) Leguminosæ", under this heading seven species are listed including *A. baileyana* (Bailey's mimosa) and *A. melanoxylon* (Blackwood). Three methods are described by means of which these can be raised: (1) by seed in early spring, with a full description how to set about it; (2) by cuttings in June–July in a close case and the methods by means of which one should get "a fair percentage" of takes; and (3) by root-cuttings in December–January in an open case with a description of the methods to adopt which will give "a fair percentage" of successes.

The Gymnosperms are dealt with in a similar manner. The book concludes with a section "Useful Tables and Other Miscellaneous Information", containing such items as a soil classification (e.g. sandy soil = less than 10 per cent clay; clay = over 30 per cent clay); a weight of soils table; a table for amounts of soil required to cover given areas to various depths, and a table giving the various sizes of English flower pots. There are two indices, a Botanical Index of 17 pages, and a General Index of six pages.

The book should be of great value to horticulturists and commercial growers in the temperate zone but to those of us in the tropics who make our living from tropical plantation crops such as coffee, tea, cinchona, tung, derris, pyrethrum, sugar cane, and sisal, information about the propagation of these is conspicuous by its absence, though the methods for the propagation of *Camellia*, particularly *C. japonica*, might be of interest to those of us who are trying to establish tea plantations by means other than that from seeds. The same can be said for species of tropical and sub-tropical forest trees whereas trees found in cooler climates are dealt with.

P.J.G.

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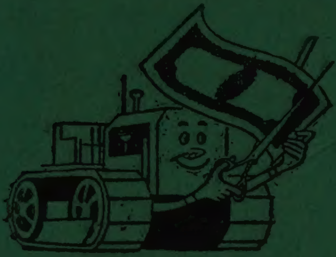

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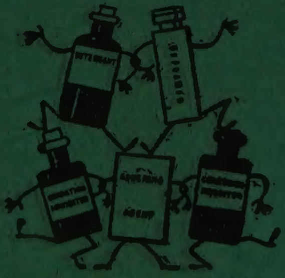

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